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ABSTRACT

Developed to serve as a way to integrate mathematics skills and science processes, this booklet provides activities which demonstrate the concept of density for students of grades five through nine. Investigations are offered on the densities of water, salt, salt water, and woods. Opportunities are also provided in computing volumes of cylinders and spheres. Each of the 26 activities have both student sheets and a teacher's guide. The teacher's guide contains information on the activities including: (1) topic area; (2) introductory statement; (3) math and science skills; (4) required materials; (5) key questions; (6) background information; (7) management details; (8) instructional procedures; (9) student procedures; (10) discussion questions; (11) activity extensions; and (12) curriculum coordinates. (ML)

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FLOATERS and SINKERS

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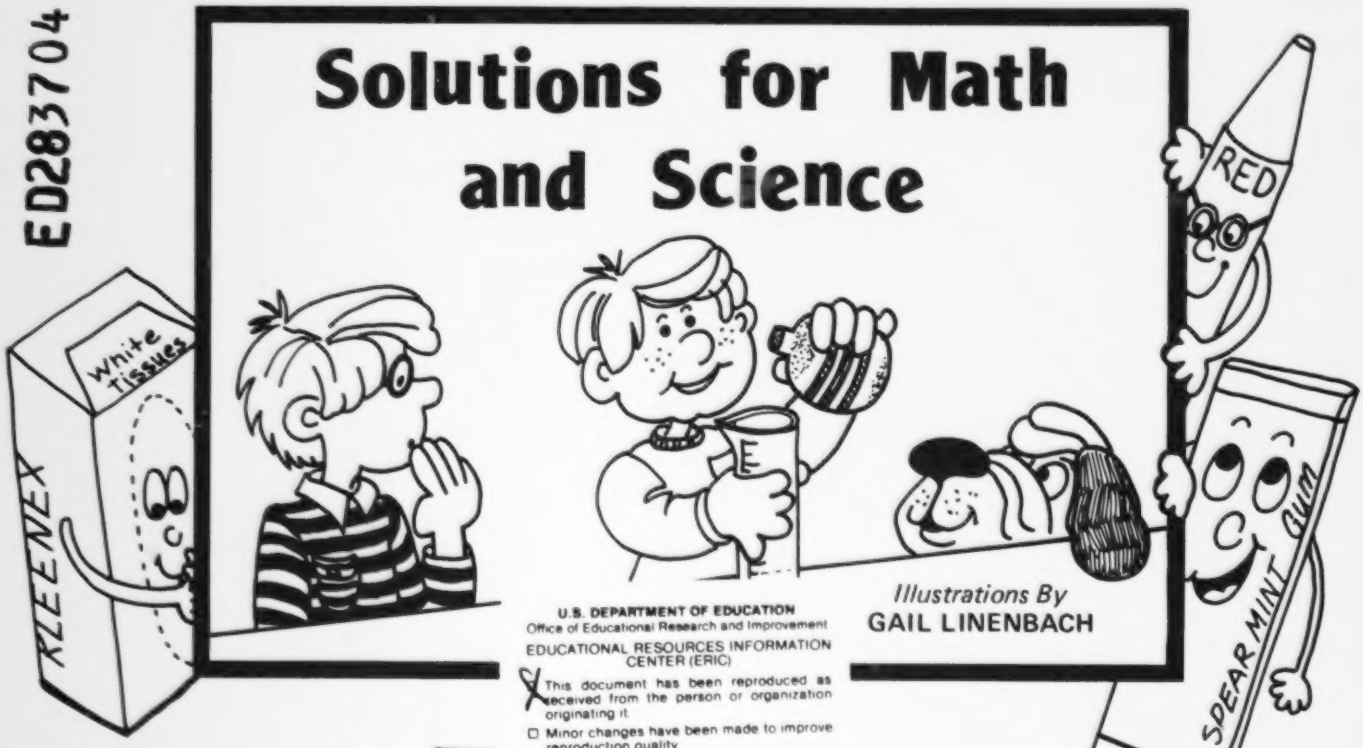
Solutions for Math and Science



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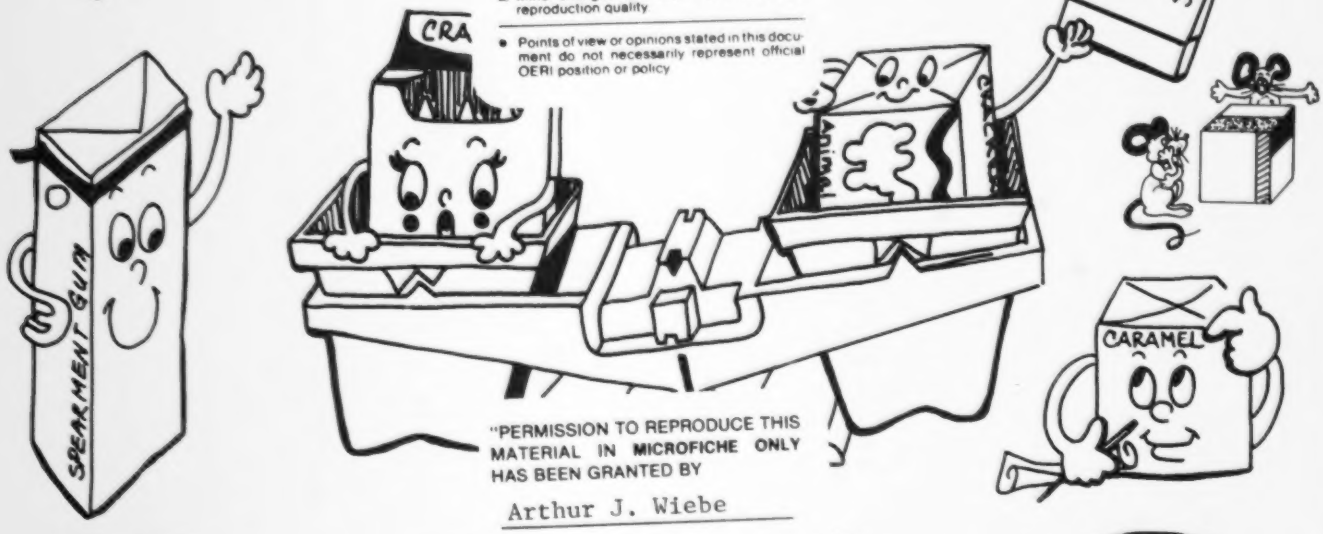

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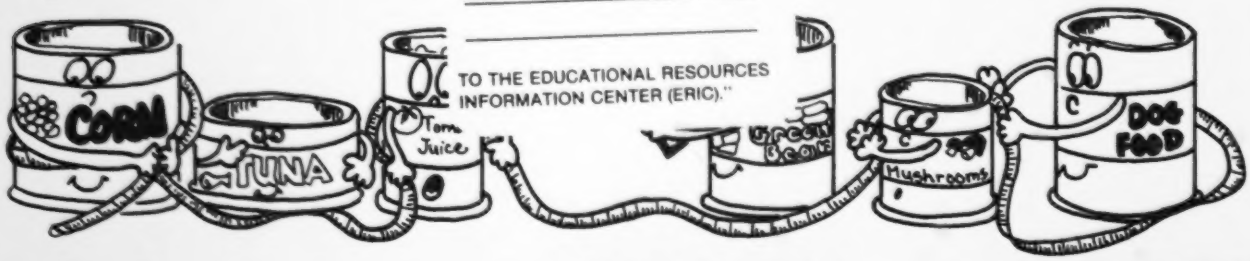

SE 040 239

Book 5

DENSITIES and VOLUMES

FLOATERS and SINKERS

Solutions for Math and Science

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Project AIMS

Project AIMS has as its purpose the integration of subject matter in K-9. Such integration enriches and makes learning meaningful and holistic. Project AIMS began as a program to integrate mathematics and science, but has since developed to also include language arts, social studies, and other disciplines. The acronym "AIMS" stands for "activities to integrate mathematics and science."

Project AIMS is a continuing, non-profit project of Fresno Pacific College. It had its inception in a National Science Foundation funded program to train teachers in the integration of mathematics and science. This quickly created the necessity to write instructional materials incorporating this concept. Despite the fact that thoughtful educators have long recommended this approach, very little appropriate material was available.

Currently, Project AIMS is funded solely through the sale of this developing series of books. All net proceeds from their sale flow into a trust fund administered by Fresno Pacific College. The use of this fund is restricted to the support of continued research and development, partial scholarships for classroom teachers who participate in the writing and field testing teams, and the publication of the books.

Two writing teams have completed their work. The first consisted of seventy-five teachers in grades 5-9 who met over a period of eighteen months. The second involved thirty-five K-4 teachers who wrote during a two-year span. In the fall of 1985 a third team of approximately fifty teachers in grades 2-9 will begin writing. In addition, over a hundred teachers have been involved in field testing newly created materials.

The rationale for this integrative thrust lies in the fact that science, mathematics, language arts, social studies, etc., are integrally interwoven in the real world outside the classroom, from which it follows that they should be similarly treated in the classroom if we are to prepare our students for life in that world. Teachers who have used Project AIMS lessons give enthusiastic endorsement to the effectiveness of this approach.

Science encompasses the art of questioning, investigating, hypothesizing, and discovering. Mathematics is the language that provides clarity, objectivity, and understanding. The language arts provide us with powerful tools of communication. Many of the major contemporary issues involve societal issues stemming from advancements in science. It is time, therefore, that all of us in the teaching profession take seriously using a more holistic mode of transmitting knowledge to students. It is this that motivates all of us who are involved in creating or using the integrative materials of Project AIMS. We invite you to join us in this effort.

Extensive field testing of these materials confirms the following beneficial results.

1. Mathematics becomes more meaningful, hence more useful, when it is applied to situations that interest students.

2. The extent to which science is studied and understood is increased, with a significant economy of time resulting from the integration of two or more disciplines.

3. There is improved quality of learning and retention, supporting the thesis that learning which is meaningful and relevant is more effective.

4. Motivation and involvement are increased dramatically as students investigate real world situations and participate actively in the process.

We invite you to become part of this classroom teacher movement by using an integrated approach and by sharing any suggestions you may have or investigations you would recommend. Project AIMS welcomes you!

Project AIMS Publications

GRADES 5-9 SERIES

Math + Science, A Solution
The Sky's the Limit
From Head to Toe
Fun With Foods
Floaters and Sinkers
Down to Earth
Our Wonderful World
Pieces and Patterns, A Patchwork in Math and Science
Out of This World, Book A

GRADES K-4 SERIES

Fall Into Math and Science
Glide Into Winter With Math and Science
Spring Into Math and Science
Seasoning Math and Science, Book A (Fall and Winter)
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Overhead and Underfoot

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I HEAR, AND I FORGET

I SEE, AND I REMEMBER

I DO, AND I UNDERSTAND

–Chinese Proverb

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Floaters and Sinkers

INTRODUCTION

This book is an effort to demonstrate the concept of density at a manageable level for grades five through eight. Volumes are constantly being calculated and division is the basic math skill used.

Students are led through a series of investigations demonstrating that space exists between particles whether seen or not seen, using larger spaces between gravel down to the smaller spaces between water molecules. The densities of water, salt and salt water are then explored.

The next series treats the density of woods in rectangular prism shapes. Included are investigations of float line and the relationship between surface area and cargo capacity of foil and clay boats.

The third case involves volumes of cylinders. After computing these volumes, students utilize this knowledge to compute densities of various things using cylinders to find their volumes.

The fourth series explores densities of spherical objects including oranges, balls, grapes, etc. Different methods of calculating volumes of spheres are also presented.

The final investigation closes the cycle by working with densities of irregularly shaped objects.

DUPLICATION RIGHTS AND RESTRICTIONS

The AIMS Education Foundation is a non-profit, tax exempt corporation. All net proceeds from the sale of Project AIMS materials are used to sustain its program of research, development, publication, dissemination and education.

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Fill 'er Up Gravel

I. **Topic Area**

Space In Matter (Gravel)

II. **Introductory Statement**

Upon completion of this investigation, students will discover that space exists between particles of gravel. While gaining practice in measuring volume, students will determine how much space there is between these particles.

III. **Math Skills**

a. Averaging
b. Finding ratio
c. Finding percent

Science Processes

a. Measuring volume
b. Estimating
c. Recording data
d. Interpreting data
e. Applying & generalizing

IV. **Materials**

For a class of 30
Four to five liters of dry gravel
Several graduated cylinders or measuring cups
Funnels (optional)
Water
Fifteen small empty cans (100 ml/6.75 oz minimum)
Pieces of cardboard or tagboard about 5 x 10 cm

V. **Key Question**

"Is there air space between the particles of gravel?" "How much?"

VI. **Background Information**

1. Although you may use British units of volume, this investigation will utilize metric units (ml).
2. Accuracy in measuring is vital if results are to be accurate.
3. In order to express the ratio of water to gravel:

$$\frac{\text{Avg. volume of water (ml)}}{\text{Avg. volume of gravel (ml)}} = \text{Ratio of water to gravel}$$

4. The volume of air space displaced is the same as the volume of water used.
5. To find the percent of space found in any given volume of gravel:

$$\frac{\text{Avg. volume of water} \times 100}{\text{Avg. volume of gravel}} = \text{Percent of Space}$$

6. To compute the average of gravel and of water used:

$$\frac{\text{Trial \#1} + \text{Trial \#2} + \text{Trial \#3}}{3} = \text{Average}$$

7. Fill 'er Up (Gravel) is a prerequisite for the investigation Fill 'er Up (Sand).

VII. **Management Suggestions**

1. Time needed: One to two forty-five minute periods.
2. Groups of two work best.
3. To reduce the amount of movement and confusion, have only one of the lab partners get the gravel, water, etc., and perform the measuring tasks while the other student records the data. Since three trials are performed, the partners could switch their roles to gain experience in both.

VIII. **Procedure**

1. Put the dry gravel in four or five separate containers. Place them on a large table or counter and near a water source. Provide a small scoop for each container. Have your measuring devices, tin cans, funnels, and cardboard in the same area. Designate a responsible student to monitor this area or do it yourself.
2. If you are using graduated cylinders, large necked funnels should be used to avoid spilling the gravel.
3. Provide a large container for the wet gravel at the completion of this investigation.

IX. **What the Students Will Do**

1. Estimate the volume of air space found in 100 ml of gravel. Record the estimate on the student worksheet.
2. Fill a graduated cylinder with *exactly* 100 ml of dry gravel.
3. Pour the gravel into a tin can. *Don't* pack the gravel. Using the cardboard carefully level the gravel on top.
4. Fill the graduated cylinder *exactly* to the 100 ml mark with water.
5. Carefully *and slowly* pour the water into the tin can until it fills exactly to the top (but not over) the level of the gravel.
6. Record the volume of water used.
7. Repeat steps 2-6 for trials two and three.
8. Find the average amount of gravel and water used, then record.
9. Determine the ratio of water to gravel as taken from the total and average rows.
10. Calculate the volume of air space displaced as taken from the total and average rows.
11. Calculate the percent of air in gravel.

X. **Discussion**

1. Could you see that space exists between the particles of gravel without having to do this investigation? (Yes)
2. For what reasons, then, did we do this investigation?
3. How can we apply the methods learned in this investigation to find if space exists in other forms of matter? Name some forms of matter to which we could apply these methods.

XI. **Extension**

1. Make a list of other items in which you could find the amount of space using the method learned here. Examples would be: different grades of gravel, soils, marbles, rice, cold cereals, etc.
2. Students could devise ways to find the amount of space in other items such as: a sponge, balsa wood, cork, fabrics, etc.
3. See the investigation "Make Room for Me" in the *Changes in Matter* booklet.
4. See the investigation "Fill 'er Up (Sand)" which follows in this booklet.

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Fill'er Up-Sand

I. Topic Area

Space in Matter (Sand)

II. Introductory Statement

The main thrust of this investigation is to teach students the concept that, even though a substance might appear to not contain any space, space does actually exist between the particles that comprise it.

III. Math Skills

a. Averaging
b. Finding ratio
c. Finding percent
d. Graphing

Science Processes

a. Estimating and predicting
b. Gathering and recording data
c. Interpreting data
d. Applying and generalizing

IV. Materials

For a class of 30
Four to five liters of dry sand
Several graduated cylinders or measuring cups
Funnels (optional)
Water
Fifteen small empty cans (100 ml/6.75 oz.)
3" x 5" cards
The completed and corrected student page from "Fill'er Up (Gravel)"

V. Key Question

"Does space exist in a substance that appears to not contain any?"
"If space does exist, how do we find out?"

VI. Background Information

1. Metric units are recommended but British units may be used if metric measuring devises are not available. This investigation is designed to be done using the metric system.
2. Encourage students to be accurate when measuring.
3. In order to express the ratio of water to sand:

$$\frac{\text{Avg. volume of water (ml)}}{\text{Avg. volume of gravel (ml)}} = \text{Ratio of water to sand}$$

4. The volume of air space displaced by water is the same as the volume of water used.
5. To find the percent of space existing in any given volume of sand:

$$\frac{\text{Avg. volume of water}}{\text{Avg. volume of sand}} \times 100 = \text{percent of space}$$

6. To compute the average volume of sand and of water used:

$$\frac{\text{Trial \#1} + \text{Trial \#2} + \text{Trial \#3}}{3} = \text{Average}$$

7. It is important to convey to the students the idea that we are experimenting to see if we can answer the key question. The basic differences between "Fill'er Up (Gravel)" and "Fill'er Up (Sand)" is that spaces could be seen between the particles of gravel but cannot be seen in sand. We simply learned a process called the water displacement method in "Fill'er Up (Gravel)". Now we are applying this method to sand and will later see that it can be applied to many porous materials.

VII. Management Suggestions

See *Management Suggestions* for "Fill'er Up (Gravel)" in this booklet.

VIII. Procedure

See *Procedure* for "Fill'er Up (Gravel)" in this booklet. Simply substitute sand for gravel.

IX. What the Students Will Do

See *What the Students Will Do* for "Fill'er Up (Gravel)" in this booklet but add:

12. Graph to compare the volume of air space displaced in gravel and sand.
13. Graph to compare the percent of air space in gravel and sand.

X. Discussion

Sand did not appear to contain any space between its particles and yet we proved that space does exist there. Do you think this shows that substances contain space even though this space might be invisible? Why or why not?

XI. Extension

1. List substances for which we *could not* use the water displacement method to see if they contain space. Examples: metals, plastics, any non-porous materials.
2. Devise methods to test for space in the substances listed in #1.
3. List substances that might contain "invisible" space to which we could apply the water displacement method.
4. Devise a method to find out if space exists in a liquid like water or alcohol.

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A Salty Solution

I. Topic Area

Space in Matter (Water)

II. Introductory Statement

Students will find that invisible space exists even among the molecules that make up water. In this investigation salt is used to fill those spaces.

III. Math Skills

a. Averaging
b. Finding ratio
c. Finding percent

Science Processes

a. Measuring volume
b. Estimating and predicting
c. Recording data
d. Applying and generalizing

IV. Materials

Per group
Clear drinking glass
50 ml iodized salt
One graduated cylinder
Water
One non-porous stirring stick (no wood)
Fine tipped felt pen

V. Key Question

A fluid (water) could be added to gravel and sand to fill up space between their particles without changing their levels. "Can a substance (salt) be added to water without changing the water's level?" "If so, how much?"

VI. Background Information

1. Space does exist among and between the molecules that make up water. Students will find that a small amount of salt can be added to water without changing its level. We use salt because, after it dissolves, the atoms of Sodium and Chlorine adhere to and combine with the Hydrogen and Oxygen atoms of water, but, at the same time, fill in spaces found among the water atoms.
2. Felt pen markings on the drinking glass should be as fine as possible.
3. Water should be at room temperature.

VII. Management Suggestions

1. The suggested time is one to two forty-five minute periods.
2. Students should work in pairs.
3. One partner should gather materials and perform the hands-on tasks while the other records the data. Partners may switch responsibilities for added experience.
4. All materials should be laid out near the water source.

VIII. Procedure

1. Students should be made aware that, when adding salt, add it *very slowly and carefully.* If too much salt is added at one time, results may not be accurate.
2. Make sure that stirring tools are absolutely non-porous. A porous material will soak up water affecting the accuracy of the outcome.

IX. What the Students Will Do

1. Pour exactly 100 ml of water into a glass. Mark the top level on the glass with a marking pen.
2. Using a dry graduated cylinder, measure 50 ml of salt.
3. Carefully pour 1 ml of salt into the water, stir and dissolve. Check the water level. Continue this process until you see the water level begin to rise. Stop adding salt when the water level begins to rise.
4. Record the amount of salt used.
5. Repeat steps 1-4 for trials 2 and 3.
6. Now, using 250 ml of water, do steps 1-5.
7. Calculate the average amount of salt used with 100 ml of water and again with 250 ml of water.
8. Calculate the ratio of salt to water for both solutions.
9. Calculate the percentage of salt in each final solution.

X. Discussion

1. Why were we able to add some salt to the water without raising its level? (Filled the spaces in water)
2. What other materials do you think would produce similar results?
3. Are there materials that could not be used? What? Why?
4. What basic change in the added material must take place for the results of this investigation to hold true? (The material must dissolve)

XI. Extension

1. Try doing this investigation using non-iodized salt: rock salt. Compare the results with those of iodized salt.
2. Do this investigation using different liquids like milk, juices, alcohol, etc., with the different salts listed. Compare results.
3. Try this investigation using various temperatures of water. Try to determine if the amount of space changes with the change in temperature.
4. For further study, see "A Super Salty Solution" found in this booklet.

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Wat~ar Densities?

I. **Topic Area**

Density and Volume

II. **Introductory Statement**

Density is defined as mass per unit volume. It is expressed in the units of grams/cubic centimeters. In this investigation students will determine the density of water.

III. **Math Skills**

a. Measuring
b. Subtracting whole numbers
d. Graphing
e. Rounding off

Science Processes

a. Measuring
b. Recording data
c. Applying and generalizing

IV. **Materials**

Graduated cylinders
300 ml of water (room temperature) per group
Metric balance and masses

V. **Key Question**

"What is the density of water?"

VI. **Background Information**

In this experiment we will be finding volume by direct measurement in a graduated cylinder. Although density is usually expressed as grams per cubic centimeter, we are still okay. At room temperature, 1 ml of water is the equivalent of 1 cubic centimeter. Therefore, just by reading how many milliliters of water you have, you will know your volume. The standard density of water is 1 g/cm³. We hope your students will find this true.

VII. **Management Suggestions**

Groups should be from two to five students. Allow about two class periods to complete this investigation, depending upon equipment available. If you have plenty of balances available, it will take less time.

VIII. **Procedure**

Have students weigh the graduated cylinder empty first and record this. Then have them fill the graduated cylinder to a specified level and reweigh. The difference will give them the mass of the water. By dividing the mass by the volume, they will find the density. Have them repeat for each given volume. By averaging their found densities, they will have the average density of water.

IX. **What the Students Will Do**

1. The students will weigh the graduated cylinder empty and record this data.
2. The students will weigh a measured volume of water in a graduated cylinder.
3. The students will find the mass of the measured volume of water by subtraction.
4. The students will find the density of the measured volume of water by division and round off to the nearest hundredth.

X. **Discussion**

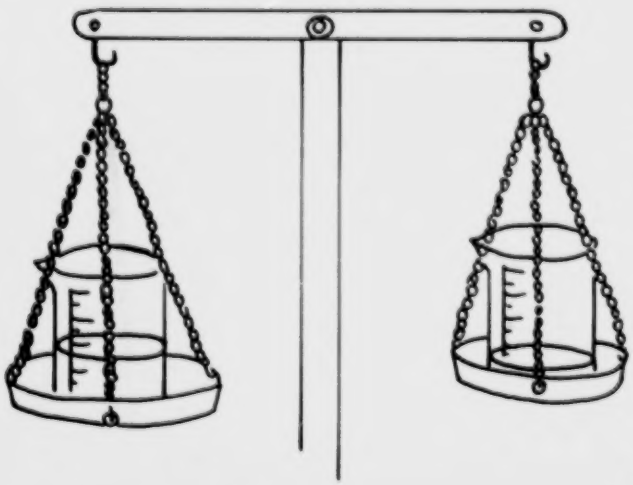
The standard density of water is 1 g/cm³. Was ours the same? If not, why do you think it wasn't? (Sample answer: Our water wasn't at room temperature. We weren't careful measuring or weighing.)

XI. **Extension**

1. Have the students graph the mass against the volume of water used. By connecting these ordered pairs, they should produce a straight line. Can they write an equation for this graph? (y = x, or mass = volume) What is the slope of this line? (1) Can they predict what 250 ml of water would weigh? (250 grams)
2. Try this experiment again using ice water or hot water. Do the densities change? (yes)
3. Have your students find the percent error between their density of water and the standard density (1 g/cm³). To find percent error:
   a. Subtract your density and the standard density
   b. Divide by the standard density
   c. Move your decimal point two places to the right and add a percent sign.

   Example: my density = 1.03 g/cm³

   a. 1.03 - 1 = .03
   b. $\frac{.03}{1} = .03$
   c. .03 = 3%



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A SALTY PROBLEM

I. **Topic Area**

Density and Volume

II. **Introductory Statement**

Density is defined as mass per unit volume. It is found by dividing the mass by the volume. It is expressed in the units of grams/cubic centimeter.

III. **Math Skills**

a. Measuring
b. Subtracting whole numbers
d. Graphing
e. Rounding off

Science Processes

a. Measuring
b. Recording data
c. Applying and generalizing

IV. **Materials**

Graduated cylinders
300 ml of table salt per group
Metric balance and masses

V. **Key Question**

"What is the density of salt?"

VI. **Background Information**

In this experiment we will be finding volume by direct measurement in a graduated cylinder. Although density is usually expressed as grams per cubic centimeter, we are still okay. A milliliter of salt will be equivalent to a cubic centimeter of salt. Therefore just change the unit from milliliters to cubic centimeters when expressing density.

VII. **Management Suggestions**

Groups should be from two to five students. Allow about two class periods to complete this investigation, depending upon equipment available. If you have plenty of balances available, it will take less time.

VIII. **Procedure**

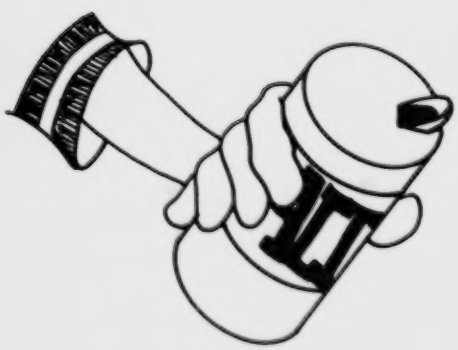
Have students weigh the graduated cylinder empty first and record this. Then have them fill the graduated cylinder to a specified level and reweigh. The difference will give them the mass of the salt. By dividing the mass by the volume, they will find the density. Have them repeat for each given volume. By averaging their found densities, they will have the average density of salt.

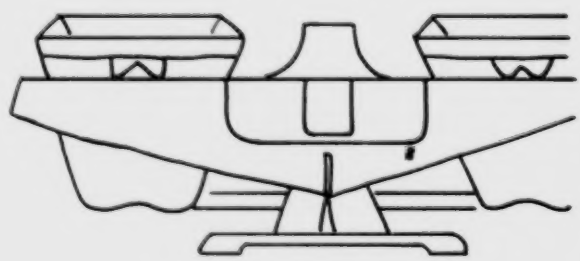
IX. **What the Students Will Do**

1. The students will weigh the graduated cylinder empty and record this data.
2. The students will weigh a measured volume of salt in a graduated cylinder.
3. The students will find the mass of the measured volume of salt by subtraction.
4. The students will find the density of the measured volume of salt by division and round off to the nearest hundreth.
5. The students will find their average density of water.

X. **Extension**

1. Have the students find the percent error between their density of salt and the standard density (1.4 g/cm³). To find percent error:
   a . Subtract your density and the standard density
   b . Divide by the standard density
   c . Move your decimal point two places to the right and add a percent sign
2. Try this experiment again using rock salt. Do the densities change? (Because of particle size, yes)
3. Have the students graph the mass against the volume of salt used. By connecting these ordered pairs, they should produce a straight line. Can they write an equation for this graph? (Yes, y = 1.4x, or mass = 1.4 volume) What is the slope of this line? (1.4) Can they predict what 250 ml of salt would weigh? (250 x 1.4 = 350)





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A SUPER SALTY SOLUTION

I. **Topic Area**

Density

II. **Introductory Statement**

Students will find that after the space among water molecules is filled, more salt can go into solution to make a saturated salt solution. They will also find that water can become so saturated that it no longer can dissolve the salt into solution. At this point we will have our super salty solution and will find the density of it.

III. **Math Skills**

a. Averaging
b. Finding ratio
c. Finding percent

Science Processes

a. Measuring volume
b. Estimating and predicting
c. Recording data
d. Applying and generalizing

IV. **Materials**

Per group
Clear drinking glass
50 ml of iodized salt
One graduated cylinder
Water
One non-wood stirring stick
Fine tipped felt pen

V. **Key Question**

Salt could be added to water without changing its level. "Can we keep adding salt indefinitely to water or is there a point where the water can no longer accept the salt?" ("Will it no longer dissolve the salt?") "If so, how much salt can we add?"

VI. **Background Information**

1. As in the lesson "A Salty Solution," the salt atoms break up into Sodium and Chlorine atoms to combine with the Hydrogen and Oxygen atoms of water. When all of the Hydrogen and Oxygen atoms have been used up, the salt will no longer dissolve.
2. Felt pen markings on the glass should be as fine as possible.
3. Water should be at room temperature.

VII. **Management Suggestions**

1. Time allowed should be one to two forty-five minute periods.
2. Students should work in pairs.
3. Students should be made aware that when adding salt, add it *very slowly and carefully.* If too much salt is added at one time the results may not be accurate.
4. You will have to stress that after the salt is added, the stirring must be done in order to help the salt dissolve.

VIII. **Procedure**

1. Put the salt in four or five separate containers around the room to avoid crowding. Have your measuring devices available here, also.
2. If you can't work near a water source, have plenty of clean, room temperature water nearby (in a bowl or container). Keep towels handy!

IX. **What the Students Will Do**

1. Pour 100 ml of water into a large graduated beaker. Mark the top level and weigh.
2. Measure 50 ml of salt into a dry graduated cylinder.
3. Add salt 1 ml at a time, stirring afterward, until the water level begins to rise. Weigh and record the weight and amount of salt used.
4. Add more salt, 1 ml at a time, until the salt will no longer dissolve.
5. Weigh and record the weight, new volume, and amount of salt used.
6. Compute the density of each solution.
7. Calculate the ratio of salt to water in each solution.
8. Calculate the percentage of salt in each solution.

X. **Discussion**

1. Why did the salt at first dissove but later stop being dissolved? (All the Hydrogen and Oxygen atoms were used up.)
2. What could be done to allow more salt to be dissolved?
3. Which solution had the larger density? Why?

XI. **Extension**

1. Try doing this investigation with non-iodized salt or rock salt. Compare your results with iodized salt.
2. Do this investigation using different liquids such as milk, juices, alcohol, etc.
3. Try this investigation using various temperatures of water. Does the water temperature change the amount of salt capable of being taken into solution?

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See Level

I. Topic Area

Density and Volume

II. Introductory Statement

Students will calculate density (specific gravity) of various liquids and use specific gravity calculations to predict where each liquid will float in a column.

III. Math Skills

a. Measuring
b. Multiplying decimals
c. Dividing decimals
d. Averaging

Science Processes

a. Measuring
b. Recording data
c. Interpreting data
d. Applying and generalizing

IV. Materials

Graduated cylinders or beakers
Triple-beam balance or other scales
Motor oil, vegetable oil, alcohol, salt
Paper towels

V. Key Question

"Which liquid will float on which?"

VI. Background Information

To calculate the density of a liquid divide the weight of the liquid sample by the volume of the sample. The following is a list of specific gravities we obtained from the investigation. ("These numbers are for comparison only, your actual mileage may differ.")

Alcohol	0.79
Motor Oil	0.85
Vegetable Oil	0.90
Water	1.00
Salt Water	1.20

To make the salt water solution, use about 200 ml of salt for each liter of water. Stir well and allow to set overnight to become as saturated as possible.

When pouring liquids to form a flotation column avoid mixing of liquids by tilting a large graduated cylinder and very gently pouring the liquids down the side. If you are careful the liquids are very cooperative about wedging themselves in where they belong. You may wish to add some food coloring to the salt solution for visibility.

VII. Management Suggestions

Have a large quantity of paper towels available to clean out beakers and accidental spills.

Have students do measurements of the oil last; water, salt water, and alcohol are easy to clean out of beakers--oil is not.

If triple-beam balances are not available, other scales can be used. Lower precision requires that the volume of liquid measured be greater to obtain accurate density calculations. If the scale will not measure less than a gram, the liquid samples should be at least 150 ml.

In place of using graduated cylinders, students can use different size cans for which they have accurately calculated the volume. If cans are used, students must be sure to completely fill the can, this can get messy because of spillage.

The estimated time for this lab is one week if class time is given to do calculations.

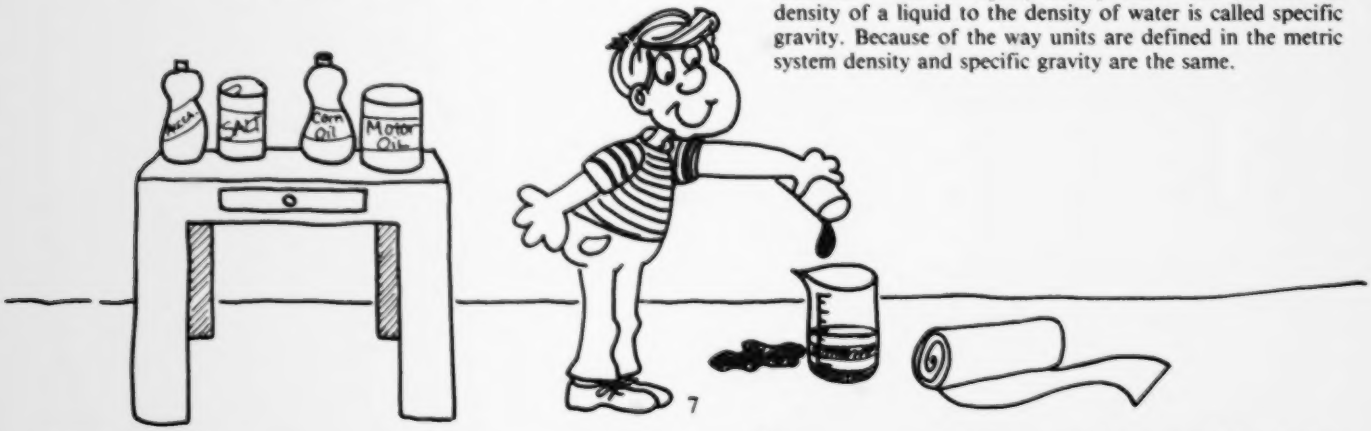
IX. What the Students Will Do

1. Weigh a clean beaker (or graduated cylinder).
2. Obtain a sample of liquid from the stock supply (50 to 200 ml).
3. Determine the volume of the liquid.
4. Weigh the beaker with liquid.
5. Repeat steps 2, 3 and 4 twice with different volumes.
6. Repeat steps 1-5 with different liquids.
7. Calculate the weight of each sample of liquid.
8. Calculate the density of each sample of liquid (density = weight/column).
9. Calculate the average density for each type of liquid.

X. Discussion

Ask students to predict which liquids would float on which if they were all poured into the same beaker. After predictions are made, make a column to test the predictions. In the process of discussion, be sure that the students recognize that the numbers they obtained as a quotient in the density calculation is the weight of 1 ml of the liquid.

A point which you may wish to bring up is that the usefulness of density measures of liquids is to predict their reaction to another liquid, usually water. The ratio of the density of a liquid to the density of water is called specific gravity. Because of the way units are defined in the metric system density and specific gravity are the same.



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Which Way Is Up?

I. **Topic Area**

Density

II. **Introductory Statement**

The students will discover that length, width and height are arbitrarily assigned terms.

III. **Math Skills**

a. Computing decimal number
b. Finding volume of prisms

Science Processes

a. Measuring
b. Gathering and recording data
c. Applying and generalizing
d. Observing and classifying

IV. **Materials**

Eight boxes or blocks with at least one pair of the same shape

Rulers or tapes for measuring

V. **Key Question**

"What is the length, width and height of each box?"

VI. **Background Information**

Students are often confused with the concept of length, width and height. This investigation is to help them visualize these concepts and their application.

VII. **Management Suggestions**

Using three colors code the l, w, and h of the boxes such that the colors converge at one corner. Label each box A, B, C, etc., for identification. The pair of boxes should be color coded differently, i.e., the longest side could be red on one box and green on the other box.

Divide the class into groups and then either rotate the students or the boxes.

To facilitate calculations for the less experienced, all measurements could be rounded off to the nearest inch or centimeter. More experienced students could use fractions, millimeters, or decimals, i.e., 3.4 cm.

VIII. **Procedure**

Place all boxes so that only one colored edge is vertical.

IX. **What the Students Will Do**

While the students are examining the boxes ask, "Which color represents the height?" Unless you followed the same color scheme on all boxes, the students will be giving different responses. This may then lead to a discovery that the box rests on its base. The longer base dimension is then called the length, and the shorter side is called the width. The height is the side perpendicular to the base. The students should now be ready to complete the chart.

X. **Discussion**

Did all lengths, widths and heights have the same color? Were there any equal dimensions with different colors? How is this explained?

XI. **Extension**

After the students have completed their work, rotate the boxes changing the position of the colors in relation to the table. Then ask the students to identify the new dimensions.

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MASSIVE BOXES

I. **Topic Area**

Density

II. **Introductory Statement**

Students need an intuitive notion of mass/weight before working with density. Students will note that mass/weight is not related to the size and shape of an object.

III. **Math Skills**

a. Estimating
b. Measuring mass
c. Subtracting
d. Dividing
e. Finding percent

Science Processes

a. Collecting and organizing data

IV. **Materials**

Pack of gum
Cracker jacks
Individual box of raisins
Animal crackers box
A Kraft caramel
Jello package
Kleenex box
Crayon box
Chalk box
Pencil box
Staple box
Balance scale

V. **Key Question**

"How much does each object weigh?"

VII. **Management Suggestions**

This can be either large or small group instruction. All weights on packages should be inked out or covered. If more than ten objects are used, ordering becomes more difficult. Since this can be done rather quickly groups could be rotated through stations.

IX. **What Students Will Do**

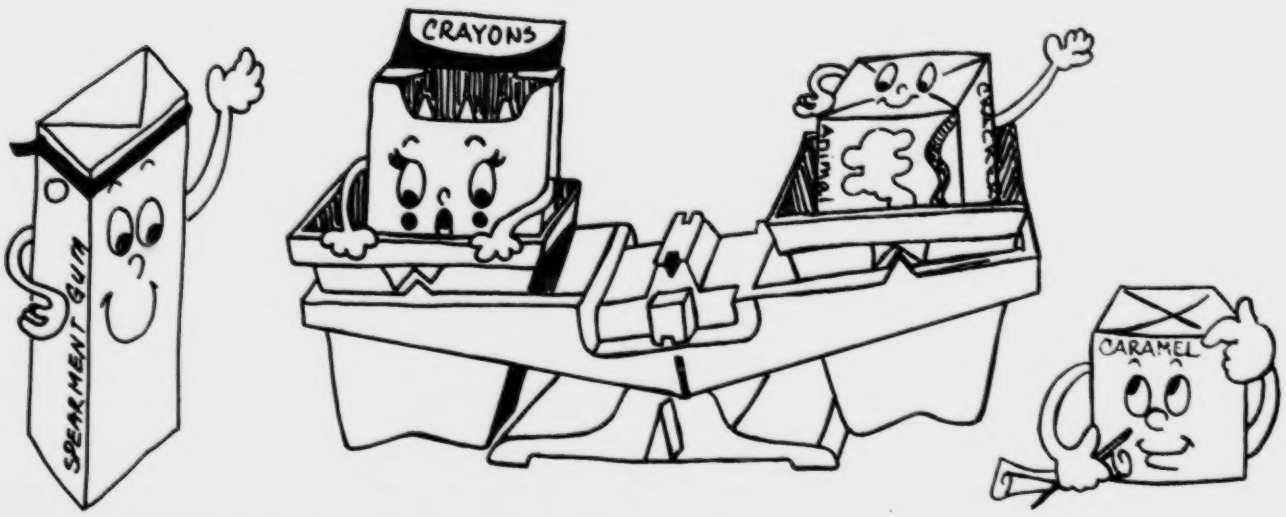
1. Estimate the mass of each object.
2. Weigh each object.

X. **Discussion**

"Who got all objects in the right order?" "Who predicted the lightest and heaviest objects correctly?" "Who guessed a correct weight?" "How close were your guesses?" "What did you discover?"

XI. **Extension**

1. Find the percent of error.
2. Sum the differences (+ & -) to rank student estimates.
3. Find the average for percent error to rank student's estimates.



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Are You As Dense As I am?

I. **Topic Area**

Density

II. **Introductory Statement**

The students will discover that density of the same kind of wood is not related to the size of the wood.

III. **Math Skills**

a. Measuring length
b. Measuring mass
c. Calculating volume

Science Processes

a. Gathering and recording data
b. Estimating

IV. **Materials**

Scales and weights
Tapes or rulers
Various sized rectangular pieces of the same kind of wood

V. **Key Question**

"Which sample will have the greatest density?"

VI. **Background Information**

The density of wood is dependent on the cell walls and the space within the cell structure. The density varies for different woods because some woods have more air space or more cell wall materials than other woods. The density of the cell wall is the amount of cell wall material in a definite volume of wood varies considerably from one kind of wood to another. For this investigation it is suggested that pine is used because of the ready availability. Varying the thickness and the length would be preferable.

VII. **Management Suggestions**

Wood samples can be obtained from wood shops at school, lumber yards and cabinet shops. Working with small groups of two or three, this investigation should take about two periods of forty-five minutes. Sample should be numbered or lettered.

VIII. **Procedure**

1. Don't tell the students that the wood is all the same.
2. Try to give one piece with knots or center grain to a group to see the difference in density.

IX. **What the Students Will Do**

1. Measure in centimeters the length, width and height of samples and record.
2. Calculate the volume of the sample using the formula V = l x w x h.
3. Measure the mass of each sample and record.
4. Find the density of each sample by using the

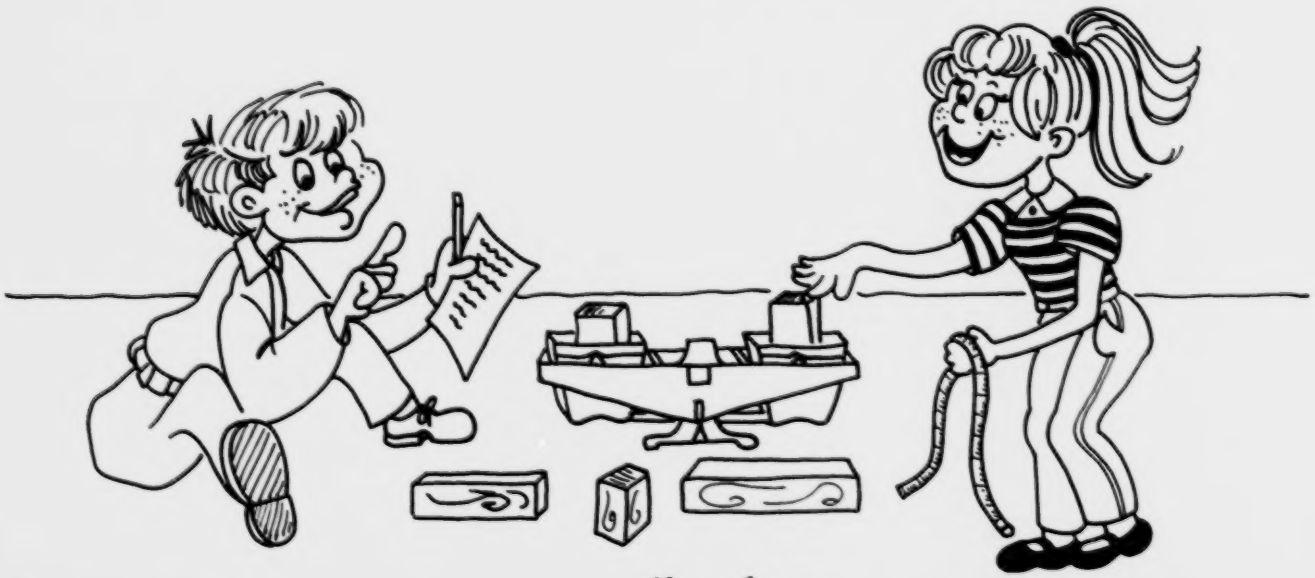
$$d = \frac{m}{v}$$

X. **Discussion**

1. Were all the densities found the same? (Should be very close).
2. If these were all cut off of the same piece of wood, why would the densities differ? (Knots and center wood are more compacted.)

XI. **Extension**

Try to obtain a piece of wood just cut and not dried yet. Compare the density of it to the density of lumberyard wood. Is there a difference? Why? (Water in the fresh wood.)



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Are You As Dense As Iam Again?

I. **Topic Area**

Density and Volume

II. **Introductory Statement**

By computing volume and density, students will learn that different kinds of woods have different densities.

III. **Math Skills**

a. Measuring length
b. Measuring mass
c. Calculating volume
d. Graphing

Science Processes

a. Estimating
b. Recording data
c. Applying and generalizing

IV. **Materials**

Scales and weights
Tape measures or metric rulers
Similarly shaped rectangular peices of various woods (know what they are samples of)

V. **Key Question**

"Why are model planes made from balsa?" "Are some woods better for certain purposes than other woods?"

VI. **Background Information**

The density of wood is dependent on the cell walls and the space within the cell structure. The density varies for different woods because some woods have more air space or more cell wall materials than other woods. The density of the cell wall is the same for all woods, about 1.5. Although this value is constant, the amount of cell wall material in a definite volume of wood varies considerably from one kind of wood to another.

VII. **Management Suggestions**

Wood samples may be obtained from school wood shops, lumber yards and cabinet shops. Working with small groups of two or three, this investigation should take about two or three periods of forty-five minutes.

VIII. **Procedure**

Come into the class and throw a balsa wood plane and then a stick. Ask the key question.

IX. **What the Students Will Do**

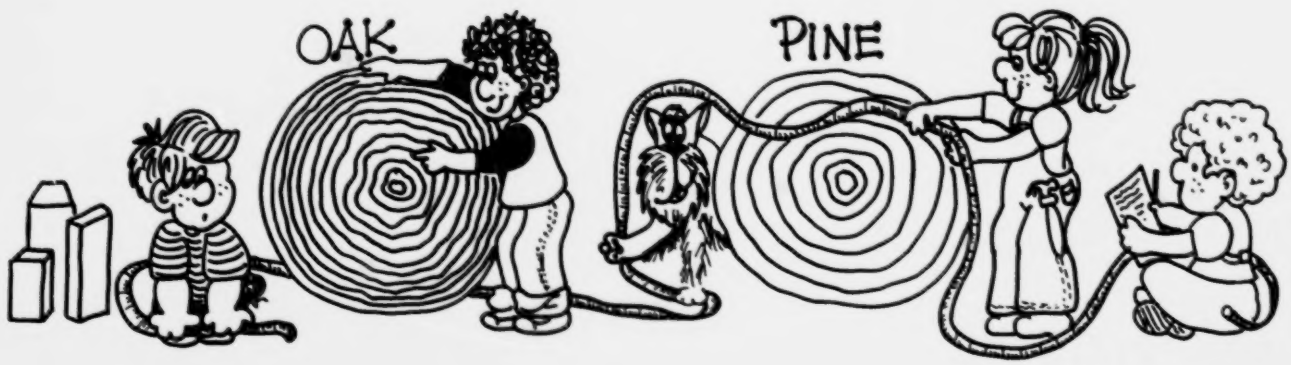
1. Measure in cm, the length, width and height of samples and record.
2. Calculate the volume of the sample using the formula V = l x w x h.
3. Measure the mass of each sample and record.
4. Find the density of each sample by using the formula D = m/v.
5. Make a density chart for the various types of wood.

X. **Discussion**

1. Which woods were the most dense? the least dense?
2. Why were they more dense? less dense?
3. In construction, which woods are used more for structural jobs? For cabinets? Why?

XI. **Extension**

1. Pick several unknown samples of wood. Find the density and identify the type of wood by comparing with the student-made chart.
2. Compare fresh cut wood with dried wood densities. What causes the differences if there are any?



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FLOATING WOOD

I. **Topic Area**

Density and Volume

II. **Introductory Statement**

Density is the measure of mass per unit volume. It is defined by the formula D = m/v.

III. **Math Skills**

a. Measuring
b. Estimating
c. Multiplying decimals and whole numbers
d. Dividing decimals and whole numbers
e. Rounding off
f. Averaging
g. Computing volumes

Science Processes

a. Measuring
b. Predicting and estimating
c. Recording data
d. Interpreting data
e. Applying and generalizing

IV. **Materials**

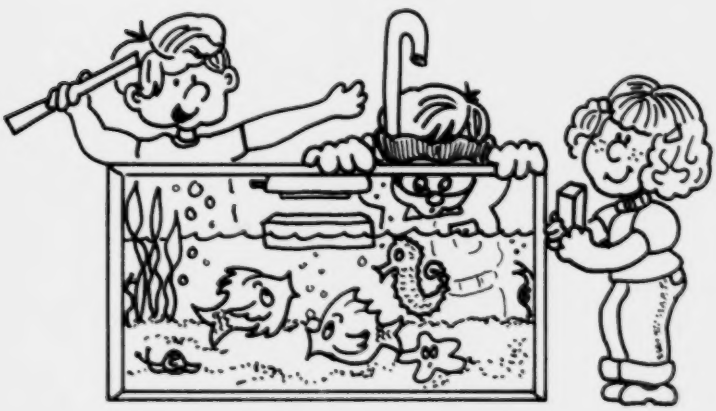
Dry pine blocks of various sizes
Metric ruler marked in millimeters and centimeters
Metric balance and gram masses
Tub of water to float wood in

V. **Key Question**

"What part of a block would be submerged if placed in water?"

VI. **Background Information**

Water has the density of 1 g/cm³ at 25° C. Anything whose density is less will float. Anything whose density is greater will sink. By computing the density of the pine block, you can find the portion that would be submerged. Example: If the density is .5 g/cm³, then 1/2 of the block would be submerged. If the density is .3 g/cm³, then about 1/3 would be submerged.



VII. **Management Suggestions**

The suggested time is thirty minutes. The suggested group size is three.

VIII. **Procedure**

1. Place several "oceans" around the room with a supply of towels nearby.
2. Let each group send a representative to choose their block.
3. Try to have a block that will not float horizontally but diagonally to show that the part submerged is still .5 or whatever your density is.

IX. **What the Students Will Do**

1. Measure and find average data for length, width and height.
2. Find the mass in grams.
3. Compute the density by dividing the mass by the volume.
4. Mark a prediction line for flotation.
5. Check prediction.

X. **Discussion**

1. What is the mass of a cubic meter of dry pine wood based upon this investigation (or whatever type of wood you used)?
2. What is the approximate mass of a truckload of dry pine wood, closely stacked, if the truck bed that is covered measured 2.5 meters by 4 meters and the stack is 1.7 meters high (all measured to the nearest tenth of a meter)?

XI. **Extension**

See "Afloat," "Ship Shape" and "Clay Boats" in this booklet.

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AFLOAT

I. Topic Area

Density and Volume

II. Introductory Statement

Students will calculate the volume of a rectangular block of wood and then calculate the density of it. By comparing its density to the density of water, they will draw a flotation line and test it.

III. Math Skills

a. Measuring
b. Estimating
c. Multiplying whole numbers and decimals
d. Dividing whole numbers and decimals
e. Rounding off
f. Averaging
g. Computing volumes
h. Finding ratios

Science Processes

a. Measuring
b. Predicting and estimating
c. Recording data
d. Interpreting data
e. Applying and generalizing

IV. Materials

Dry rectangular blocks of wood
Metric rulers
Metric balance and gram masses
Tub of water to float wood in
Salt

V. Key Question

"What happens when a ship goes from fresh water into salt water?"

VI. Background Information

Tap water has the density of 1 g/cm³ at room temperature. Salt water has the density of 1.2 g/cm³ if prepared the following way:

> Add salt a little at a time to your tap water, stirring to dissolve. Stop when you see that the salt is no longer dissolving. You now have a super-saturated solution of salt water.

An object will float higher in salt water than in tap water. By comparing the density of the wood to the water it will be floated in, you can figure how much of the wood will be in the water. The ratio of the densities will give you what protion of the block will be under water.

Example: The density of wood is .6 g/cm³

The density of tap water is 1 g/cm³

$$\text{The ratio } \frac{\text{density of wood}}{\text{density of water}} = \frac{.6}{1.0} = .6$$

Therefore 6/10 of the wood would be under water. Mark a line 6/10 of the way and try it!

$$\text{The ratio } \frac{\text{density of wood}}{\text{density of water}} = \frac{.6}{1.2} = .5$$

Therefore 5/10 or 1/2 of the wood is under water. Mark a line and check.

VII. Management Suggestions

Students should work in pairs or individually. This can be done in one class period or two, depending on the skill of the students and equipment available. Have the students try their wooden ships in tap water and then change the tap water to salt water. Tell the students to remove the wood as soon as possible from the tap water to avoid absorption of water causing a weight change.

VIII. Procedure

1. Have the students find the mass and volume of their block of wood.
2. Have them mark a line showing where it will float in tap water.
3. If they were correct, fine. If not, have them mark the correct place with another color.
4. If they have done the two previous investigations, "Wat-ar Densities" and "A Salty Solution," they will know that the fresh water and salt water densities are different. If you haven't done these, read "Background Information."
5. Have them repeat the first part with salt water.

IX. What the Students Will Do

1. Find the volume and mass of their block of wood.
2. Find the density of their wood.
3. Find the ratio of the wood's density to the water's density.
4. Mark a line showing where it will float.
5. Float the block to check their accuracy and make any line corrections necessary.
6. Repeat steps 3-5 using salt water.

X. Discussion

1. What happened to the water line from tap water to salt water? (The line went up.)
2. Does this happen to ships? (Yes)
3. What would ships have to worry about most--coming into port or leaving port? (Coming into port from salt water to fresh water. They will sink further into the water. They need to make sure their cargo isn't so heavy to make their ship hit bottom.)

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SHIP SHAPE

I. **Topic Area**

Problem Solving

II. **Introductory Statement**

The purpose of this activity is for the students to apply understanding of volume to a problem solving situation. The students are given a limited amount of aluminum foil and asked to design their own barge to float the maximum amount of cargo. They are given time to experiment and alter their design. Before submitting their final design they must predict, from their calculated displacement (volume), the amount of cargo the ship will be able to float. They then test their prediction by floating and loading the barge.

III. **Math Skills**

a. Multiplying decimals
b. Computing area and volume

Science Processes

a. Recording data
b. Interpreting data
c. Applying and generalizing

IV. **Materials**

Aluminum foil, heavy duty
Tape
Scissors
Straws (optional)
Metric rulers with mm markings
Materials for cargo of known weight (e.g., centicubes or mosaic tiles)
Basins or sinks for floating barges
Water

V. **Key Question**

"What is the largest amount of cargo you can float using one sheet of aluminum foil?"

VI. **Background Information**

The volume of the ship is calculated by multiplying the area of the bottom of the ship times the draft (depth of the boat below the water line). Archimede's principle of bouyancy tells us that the weight which can be floated is equal to the weight of the water displaced by the vessel.

VII. **Management Suggestions**

Time needed: one class period
Groups of two are best

VIII. **Procedure**

1. Cut foil into manageable sizes (10 cm x 10 cm). This allows for a countable number of cargo to be floated. Have enough so that students can experiment several times.
2. Have plenty of towels handy and remind students that if their cargo sinks, it should be dried before reused.
3. Remind students that 1 cc = 1 g.

IX. **What the Students Will Do**

1. Using paper, experiment with designs and calculations to find the best design for your barge.
2. Using foil, carefully construct your barge so that it is water tight and stable in the water.
3. Calculate the amount of cargo which your ship will carry. Do not forget that the calculation of volume gives the total amount the ship will float; the weight of the ship itself must be included in that amount.
4. Fill out the vessel license application and present application and vessel to the inspector prior to the launching.

X. **Discussion**

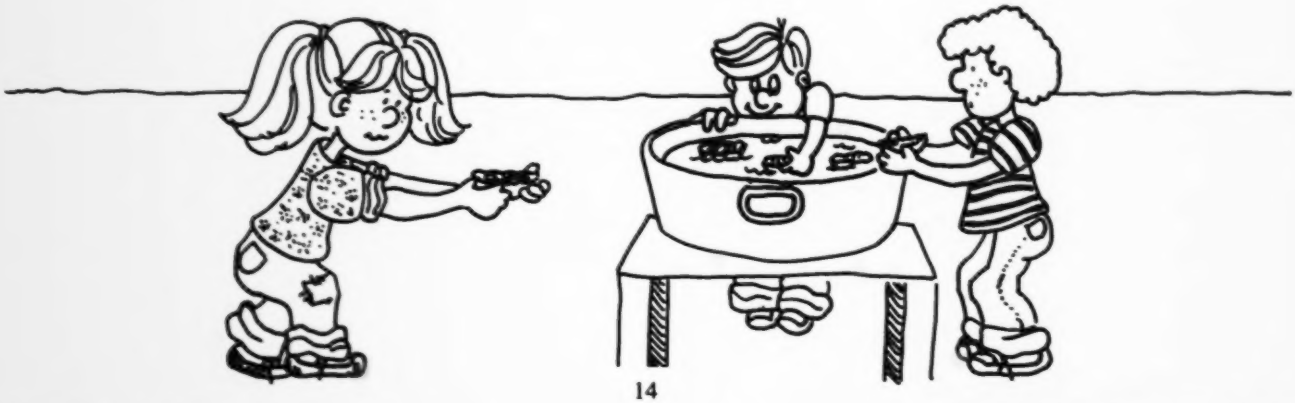
Differences in dimensions will give rise to the opportunity for discussion of optimal draft vs. area of bottom, i.e., too much depth will cause the area of the bottom to reduce disproportionately and reduce the total volume. Differences in design will give rise to discussion of optimal shape for stability and ability of construction.

XI. **Extension**

Once the barge is constructed the students can also calculate how much the barge could carry on the ocean rather than on fresh water.

Straws can be used for structural reinforcement of the barge. If this reinforcement is allowed, a building regulation should be enforced that all supplementary material be inside the foil hull; otherwise, straws can be sealed and used as flotation pontoons.

To create an ocean, mix a salt water solution. Dissolving 200 ml of salt per 1 liter of water will give a saturated salt solution. Then have the students calculate the density of that solution. Density is calculated by weighing a sample of the salt water and dividing the weight by the volume of the solution. The density is in g/ml, so the flotation capacity of the ship would be obtained by multiplying the ship's volume times the density of the water.



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Clay Boats

I. **Topic Area**

Density and Volume

II. **Introductory Statement**

Archimede's Principle says that any object wholly or partially immersed in a liquid is buoyed up by a force equal to the weight of the liquid displaced.

III. **Math Skills**

a. Measuring
b. Estimating
c. Graphing

Science Processes

a. Measuring
b. Predicting and estimating
c. Recording data
d. Applying and generalizing

IV. **Materials**

Balls of plasticene clay of same weight
Containers for water (bowls, pans, gallon-size milk cartons with top cut off)
Uniform weights (titles, centimeter cubes, marbles, pennies, plastic cowboys and Indians, beans)

V. **Key Question**

"What shapes of clay float best?" "How much weight can a clay boat of 30 grams (or an ounce) hold?" Grabber: hold up a ball of clay and toss it into a sea of water. It sinks of course. Ask the students how they could make it float.

VI. **Background Information**

You should know that you need sides on your boat and that the best shape is a cup shape. This project can get a little messy--have lots of paper towels handy! After a boat is filled and sinks, dry the contents and boat insides off.

VII. **Management Suggestions**

Groups of two or three are nice. Allow about forty-five minutes with time to do free play with the clay at the beginning. Encourage the groups to name their vessels.

VIII. **Procedure**

Give each group 30 grams of clay. Have them make shapes using all of the 30 grams until they find a shape that floats empty. Now have them add weights until it sinks. They have three tries to improve their score. The boat that holds the most after three tries wins.

IX. **What the Students Will Do**

1. The students will learn which geometric shape will hold the most (volume) and will still float.
2. The students will find the difference between the weight of their boat and the cargo.
3. The students will draw and describe their shapes used.

X. **Discussion**

1. In the boats that floated, which weighed more: the boat or the cargo?
2. How about those that sank?
3. Is their a critical weight factor?
4. What other factors may have determined floatability?

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The Orange's Secret

I. **Topic Area**

Density

II. **Introductory Statement**

If an orange is placed in water, will it sink or float? What happens when the orange is peeled and then placed in water? Questions such as this will be investigated in this study. The answers are found through determining the density of the objects in question.

III. **Math Skills**

a. Finding the volume of oranges in cubic centimeters by displacement
b. Finding the mass of oranges in grams by weighing
c. Computing the density using the formula D = m/v

Science Processes

a. Predicting
b. Observing
c. Measuring
d. Controlling variables
e. Recording data
f. Interpreting data
g. Applying and generalizing

IV. **Materials**

Supply of oranges
Balance and masses
Large graduated cylinder (large enough so the orange fits inside) or graduated cubic liter
Student worksheets

V. **Key Questions**

"If an orange is placed in water, will it float or sink?" "If the orange is peeled, will it float or sink?" "If the orange floats, what part of it is above the water line?" "Is the density of oranges predictable?"

VI. **Background Information**

Density is the measure of mass per unit volume. It is defined by the formula D = m/v. When *m (mass)* is measured in grams and *v (volume)* in cubic centimeters, density is expressed in grams per cubic centimeter. It can also be thought of as the ratio of mass to volume.

Fresh water at 4° C has a density of 1 gram per cubic centimeter. An object with a lesser density will float and one with a greater density will sink in fresh water at that temperature.

VII. **Management Suggestion**

Have students work in groups of three or four. Supply each group with all of the materials. If only one set of materials is available, groups may be rotated through the investigation and results compared when all have finished. The time required for each investigation is fifteen to twenty-five minutes.

VIII. **Procedure**

1. Set up each station with the materials listed.
2. Find the mass of each orange in grams by weighing on the balance. Record the result.
3. Fill the graduated cylinder or cube with water so the depth is a little less than the diameter of the orange. Record this reading.
4. Place the orange in the water. If it floats, force it down with the eraser end of a pencil until it is just submerged and read the water depth and record.
5. Find the difference of Step 4 - Step 3 and record. This is the volume of the orange. (If part of the pencil is submerged a slight error is introduced, hence the caution to just submerge the orange.)
6. Find the density of the orange using the formula D = m/v.
7. Repeat these steps for four more oranges and find the average density.
8. Peel the oranges and repeat the above steps to find the average density of peeled oranges.

IX. **What the Students Will Do**

The students will follow the procedure outlined above by following instructions on the student worksheets.

X. **Discussion**

Student will answer the key questions.

XI. **Extension**

Students may wish to investigate the density of apples, bananas, nuts and other fruits.

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Can You Tell?

I. **Topic Area**

Density and Volume

II. **Introductory Statement**

Density is the measure of mass per unit volume. In this investigation we are dealing with cylinders and trying to illustrate that cylinders are very complicated to rank order as to volume.

III. **Math Skills**

a. Estimating
b. Measuring

Science Processes

a. Classifying
b. Measuring
c. Estimating
d. Recording data
e. Interpreting data
f. Applying generalizing

IV. **Materials**

Empty pill bottles or cans of varying heights and diameters
Graduated cylinder

V. **Key Question**

"Can you tell, just by looking, which will hold the most water?"

VI. **Background Information**

Density is the measure of mass per unit volume. It is defined by the formula $D = m/v$. Students will need to have an intuitive feeling for volume. In cylinders, this is most difficult. This investigation should give the children some experiences with cylinders and volume. They will learn that you must consider both the height and diameter of the cylinder which will lead them to the formula of the volume of a cylinder which is $\pi r^2 h$.

VII. **Management Suggestions**

This is a good investigation to do with the class as a whole unit or as an independent unit for groups. You will only need fifteen to twenty minutes for this investigation.

VIII. **Procedure**

Have the items to be used before the class. Ask the students to rank order them according to the volume they hold. Ask the students to estimate the volume of each cylinder. Have a student fill each cylinder with water and then pour the contents into a graduated cylinder to find the volume. Put the cylinders in order according to volume. Have students check to see how many they got right. Have the students find the difference between the actual and their estimate.

IX. **What the Students Will Do**

1. Write down the letters of the cylinders from smallest volume to greatest volume.
2. Estimate the volume of each in ml (milliliters).
3. Record your estimate and the actual volume.
4. Find the difference between your estimate and the actual.

X. **Discussion**

1. Which held more water than you thought? Which was lighter?
2. Why wasn't the tallest one the greatest in volume?

XI. **Extension**

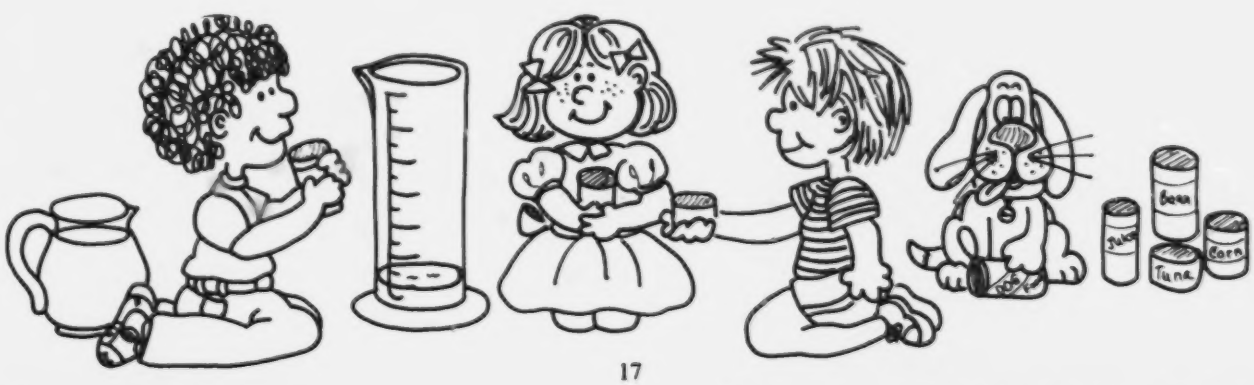
1. Find the class average of each guess and see how close it was to the actual volume.
2. Have the students find the percent error in their individual guesses and then in the class average guesses.

Example: My estimate 125 ml
Actual 130 ml

a. find the difference: 130 - 125 = 5 ml

b. divide this answer by the actual (round off to the nearest hundredth) $\frac{5}{130} = .04$

c. move the decimal point 2 places to the right: .04 = 4%



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TIN CAN SPACE

I. Topic Area

Volume and Density

II. Introductory Statement

The purpose of this activity is to allow the students to verify the results of calculation of volume with the physical world.

III. Math Skills

a. Multiplying decimals
b. Calculating area
c. Calculating volume
d. Calculating percent of error

Science Processes

a. Estimating
b. Recording data
c. Interpreting data

IV. Materials

Cans of assorted sizes
Metric rulers or tapes with mm markings
Graduated cylinders or graduated beakers

V. Key Question

"How accurately can you measure and calculate volume?"

VI. Background Information

Before doing this activity students should understand the concept that volume is given by area of a base times height and that 1 cubic centimeter equals 1 milliliter.

Area of a circle = (pi) x r^2

Volume of a cylinder = Area of circle x height of cylinder

VII. Management Suggestions

Cans should be labeled so that students can refer back to the same can when verifying calculations by direct measurement of volume. Be sure that small graduated cylinders are available so that students can obtain measurements of liquid to at least 1 ml accuracy.

The estimated time for this activity is two class periods plus time for calculations of volume which, of course, could be done as homework between lab activities.

VIII. Procedure

1. Obtain at least six different sized cans and label with letters or numbers.
2. Advise students to measure as accurately as possible.
3. Provide calculators for less capable students to use.
4. Remind students to copy down the correct number or letter of the cans used so that they can check their volumes in the second part of the investigation.

IX. What the Students Will Do

1. Measure the diameter of the can to the nearest mm.
2. Measure the height of the can to the nearest mm.
3. Calculate the area of the can (A = π x r^2).
4. Calculate the volume of the can (V = A x h).
5. Fill the can with water and measure the volume with a graduated cylinder or graduated beaker.
6. Calculate the percent error by the following steps:
   a. subtract the measured volume and the calculated volume (smaller from larger)
   b. divide step *a* by measured volume
   c. multiply step *b* by 100.

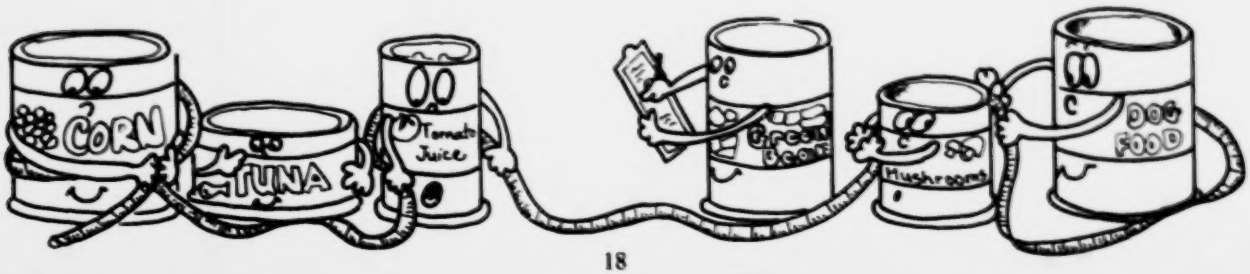
X. Discussion

"You probably did not get all of the calculated volumes to be exactly the same as your measured volumes. What could cause their error?" (Some error is built in by limitations of accuracy of the equipment. The measurements were made from the outisde of the can so there was an error caused by the thickness of the metal and height of the lip of the can. Other sources of error would be careless measurements, spillage and not filling the can to the top.)

The concept of acceptable margin of error is an important one when students begin to quantify experimental results. Calculation of experimental error is too complex to be introduced here; however, percent error should allow students to develop an understanding that there will always be some small error but that is not an excuse for sloppy work which leads to large errors. Reasonably careful work should hold the error under 5%.

XI. Extension

In place of checking volume by measuring, fill the can with water and weigh using an accurate balance. Subtract the weight of the empty can from the weight of the full can. Since 1 cc = 1 g of water, this will give a more precise indication of volume.



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How much cargo will it hold?

I. **Topic Area**

Volume and Density

II. **Introductory Statement**

Students will calculate the volume of the cylindrical container and calculate the density of a variety of solids.

III. **Math Skills**

a. Calculating with decimals
b. Calculating area of circle
c. Calculating volume of cylinder
d. Calculating density
e. Calculating average

Science Processes

a. Measuring
b. Recording data
c. Interpreting data
d. Applying and generalizing

IV. **Materials**

Variety of cans (at least 3 different)
Metric rulers or tape measures with mm markings
Scale
Salt, flour, rice, oats, beans

V. **Key Question**

"If you owned an ocean liner, would you charge the same rate for each of these things?" "If your liner held 1000 cubic meters and you charged per cubic meter, how much would you charge to carry these items?"

VI. **Background Information**

Density is the ratio of mass to volume. It is calculated by dividing weight by volume.

Area of a circle is calculated by Pi (π) times the radius to the second power ($A = \pi \times r^2$).

Volume of a cylinder is calculated by multiplying the area of the base (circle) times the height of the cylinder.

Students must understand that the amount of cargo that a ship can carry is related to the volume of cargo area available and the weight which the ship can float. For the purpose of the activity it would be sufficient to state the parameters for the ship the students are to consider. To be consistent with the units the students will be using in the activity, keep the amounts small. (In our key question, we suggest 1000 m^3. You might want to gear it down to 1000 cc.)

VII. **Management Suggestions**

Be sure that cans are labeled so that students can refer back to the same can at different parts of the activity.

Time allowed should be one to two class periods.

VIII. **Procedure**

1. Have the solid materials in containers at one table.
2. Have the scales at another table.
3. Have the cans labeled so they are easily recognizable.

IX. **What the Students Will Do**

1. Measure the diameter and height of a can and record in the data table.
2. Calculate the volume of the can.
3. Repeat steps 1 and 2 with two different cans.
4. Weigh the empty can.
5. Fill the can with one of the solid materials.
6. Weigh the full container.
7. Calculate the density of the solid.
8. Repeat steps 4-7 with each solid.

X. **Discussion**

From calculating the densities of the solids the students should realize that if the same rate was applied to all cargo the ship would not fairly earn all that it could. If the rate was only to be based on weight, light materials, especially those with a density less than 1, would fill the ship causing it to make voyage earning less than its maximum capacity. If the rate was only to be based on volume, heavy materials would weigh down the ship without using all the volume capacity, so the ship would earn less than it should. Through a class discussion, students should be able to generate a price structure based on the density of the cargo to be shipped.

XI. **Extension**

The consideration of liquid cargoes and salt water voyages which increase the weight capacity of the ship several percent gives the opportunity to extend the discussion or even a recalculation of the price chart as an extension of this activity.

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I. **Topic Area**

Density and Volume of Spheres

II. **Introductory Statement**

Density is the measure of mass per unit volume. In this investigation students will find that just because something is bigger it isn't heavier!

III. **Math Skills**

a. Subtracting
b. Averaging
c. Estimating
d. Measuring
e. Finding percent error

Science Processes

a. Classifying
b. Measuring
c. Estimating
d. Recording data
e. Interpreting data
f. Applying and generalizing

IV. **Materials**

Jaw breakers, oranges, grapefruits, popcorn balls, tomatoes, grapes, cranberries, onions or any other spherical-shaped fruits, vegetables or foods.

Metric balance and masses.

V. **Key Question**

"Does size tell you heaviness?"

VI. **Background Information**

Density is the measure of mass per unit volume. It is defined by the formula D = m/v. Students need to have an intuitive feeling for mass. This should be acquired through this investigation. The children will discover that something is not heavier just because it is bigger, but that there is something else to consider. That something is density.

VII. **Management Suggestions**

Allow approximately one class period for the basic investigation. This can be done as a whole class activity. Have a small group of students lead the class. Let one hold the objects up as the remainder of the class write down their estimates. While this is going on, another student could be putting the diagram on the board. The other two students could be setting up the scales and weighing the objects as the leader finishes showing it. Percent error should be calculated only as an extension activity with students capable of it.

VIII. **Procedure**

Have the students write down the objects in order from lightest to heaviest only by sight. Have them estimate the mass of each object in grams. After each object has been massed, have the students find the difference between their estimate and the actual mass. Those that are able can compute the percent error for each object.

IX. **What the Students Will Do**

1. Write the objects down from lightest to heaviest and estimate the mass of each.
2. The students will find the difference between their estimate and the actual mass.

X. **Discussion**

1. Which was heavier than you thought? Which was lighter?
2. Why wasn't the biggest one the heaviest?
3. If these all had the same volume (been the same size), would the order change?
4. How could we find out? (Find their densities)

XI. **Extension**

1. Find the class average of each guess and see how close it was to the actual mass.
2. Have the students find the percent error in their individual guesses and then in the class average guesses.

   Example: $\frac{\text{estimate}}{72 \text{ grams}}$ $\frac{\text{actual}}{100 \text{ grams}}$

   a. find the difference: 100 - 72 = 28 grams

   b. divide this answer by the actual: $\frac{28}{100} = .28$ (round off to the nearest hundredth)

   c. move the decimal point 2 places to the right: .28 = 28%

3. After using edible objects, have the students try this with balls of different materials.

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FRUIT SALAD

I. Topic Area

Density and Volume of Spheres

II. Introductory Statement

Density is the measure of mass per unit volume. It is defined by the formula D = m/v. Students should be able to find the volume of a sphere by several methods. The method we will investigate will be direct measurement of diameter and application of the volume formula.

III. Math Skills

a. Measuring
b. Multiplying decimals and fractions
c. Dividing decimals and fractions

Science Processes

a. Measuring
b. Predicting and estimating
c. Recording data
d. Interpreting data
e. Applying and generalizing

IV. Materials

Cherry tomatoes and grapes
Two wooden blocks
Metric balance and masses

V. Key Question

"Does a spoonful of tomato have the same mass as a spoonful of grape?"

VI. Background Information

Density isn't just how heavy something is. You could think of density as the weight of one spoonful of something compared to the weight of one spoonful of something else. Does a spoonful of tomato have the same mass as a spoonful of grape?

VII. Management Suggestions

Have the students form into groups of four. Let them be either cherry tomatoes or grapes. In each group you will have a diameter measurer and helper, a masser and a recorder. Allow one class period for this activity. Calculations may be finished for homework or the next day.

VIII. Procedure

Give each group five samples of their fruit choice. Have them find the mass of each. By placing the fruit between two wooden blocks or books, they will find the diameter (the distance between these objects). Have them find the density and the average density for their five samples.

IX. What the Students Will Do

1. The students will mass the fruit.
2. The students will find the diameter of the fruit sample and then apply the formula $V = 4/3\ r^3$ (where r = radius or half the diameter).
3. By dividing the mass by the volume, the students will find the density of their fruit sample.
4. The students will find the average density of their five samples.
5. The students will decide if a spoonful of tomato would be heavier or lighter than a spoonful of grape.

X. Discussion

1. Do the densities of the tomatoes differ greatly?
2. Do the densities of the grapes differ greatly?
3. Which is more dense, grapes or cherry tomatoes?
4. Which do you think would be heavier: a spoonful of tomato or a spoonful of grape?
5. If tomatoes and grapes were the same price, which would cost more: a cup of grapes or a cup of tomatoes?

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JUST A SPOONFUL

I. **Topic Area**

Density and Volume of Spheres

II. **Introductory Statement**

Density is the measure of mass per unit volume. It is defined by the formula D = m/v (density equals mass divided by volume). Students should be able to measure the volume of a sphere by several methods. One of these is by direct measurement of amount of liquid held. Remember, 1 milliliter of water at room temperature is equal to 1 cubic centimeter of water.

III. **Math Skills**

a. Measuring
b. Estimating
c. Dividing whole numbers
d. Graphing
e. Finding slope and writing equations

Science Processes

a. Measuring
b. Predicting and estimating
c. Recording data
d. Interpreting data
e. Applying and generalizing

IV. **Materials**

A different sized spherical Christmas ornament for each group

Several liquids: water, salt water, alcohol, milk, hot water, ice water, etc.

Metric balance with masses

Graduated cylinder

V. **Key Question**

"Does a spoonful of water weigh the same as a spoonful of alcohol?"

VI. **Background Information**

In this investigation we are controlling the volume of the sphere. The density will vary due to the mass of the liquids. The heavier liquid will be the heavier density.

VII. **Management Suggestions**

Work with as many groups as you like. Suggested class time is 30 minutes. More time might be needed to do extensions. If you are going to graph the volume against the mass to find the density, you will need about five different sized ornaments.

VIII. **Procedure**

Give each group a different sized Christmas ornament. Have several liquids at the front of the classroom. Let each group come up and get enough of each liquid to do their experiments. Have each group mass their ornament empty and then fill it up with a liquid. By massing it full and finding the difference they will have the mass of the liquid. By transfering the liquid to a graduated cylinder they will find the volume of the ornament. When they divide the mass by the volume they will find the density of the liquid. Have them repeat with several liquids.

IX. **What the Students Will Do**

1. The students will estimate the volume of the ornament.
2. The students will estimate the density of the liquids.
3. The students will mass the ornament both empty and full.
4. The students will measure the volume in milliliters and change to cubic centimeters for the density calculation.
5. The students find the density by dividing the mass of the liquid by the volume of liquid.
6. The students will compare the liquids and densities and find that the same volume of alcohol will be lighter than an equal volume of water.

X. **Discussion**

1. Which liquid has the greatest density? the least density?
2. Did each group obtain the same densities for the same liquids?
3. Which liquids float on water?
4. On which will water float?

XI. **Extension**

1. Make a bar graph showing the various densities of the liquids.
2. Obtain the data from other groups about a certain liquid. Graph the volume of liquid against the mass of the liquid. What type of graph results? (Should be a line) What is the slope of this line? Can you write an equation to show the relationship between mass and volume for this liquid?

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IT'S YOUR LOSS

I. Topic Area

Density and Volume of Spheres

II. Introductory Statement

Density is the measure of mass per unit volume. It is defined by the formula D = m/v. Students should be able to measure the volume of a sphere by several methods. One of these is by the amount of water displaced when a sphere is submerged in water.

III. Math Skills

a. Measuring
b. Estimating
c. Dividing
d. Rounding off
e. Multiplying fractions
f. Cubing a number

Science Processes

a. Measuring
b. Predicting and estimating
c. Recording data
d. Interpreting data
e. Applying and generalizing

IV. Materials

Playground balls such as high density balls, ping pong balls or jack balls or small spherical shaped objects such as cherry tomatoes.

Graduated cylinder.

Metric balance and gram masses.

V. Key Question

"Do heavier objects displace more water?"

VI. Background Information

The amount of water displaced will be equal to the volume of the sphere. Some balls may have to be pushed under the water level to displace the water. Be careful not to displace more than should be with these types of balls. The density of the ball will not have any consequence on the amount of water displace. NOTE: 1 cubic centimeter equals 1 milliliter of water at 25° C (room temperature).

VII. Management Suggestions

This can be done as a class activity or in small groups. Suggested class time is thirty minutes to complete calculations. If extensions are done, more time will be needed.

VIII. Procedure

Have the objects before the class or group and ask them to list them according to how much they will make the water line move when placed in the graduated cylinder. Have them estimate how many milliliters it will move. Let volunteers plunge the objects and measure the displacement. (Fill the cylinder to a certain level, record this level, drop object in, record new level, subtract the two levels to find the displacement.) Have another student mass the object and record it. By dividing the mass by the displacement (volume) you will obtain the density. (Remember that 1 milliliter is equal to 1 cubic centimeter at room temperature. If your displacement is 15 milliliters, then the volume of the sphere is 15 cubic centimeters.)

IX. What the Students Will Do

1. The students will estimate the displacement in milliliters.
2. The students will find the actual displacement.
3. The students will mass the object.
4. The students will find the density by dividing the mass by the displacement (volume).
5. The students will compare the objects and densities and find that the larger spheres displace more but are not necessarily heavier.

X. Discussion

1. Which object displaced more water?
2. Which is the heavier object?
3. Are the answers to 1 and 2 the same?
4. Which is the largest object?
5. Are the answers to 1 and 4 the same?
6. What causes water displacement? (size, heaviness, color?)
7. Can we use this method to find the volume of every spherical object? Why not?

XI. Extension

1. After students have discussed why this method won't work with every object, you might want to introduce the formula for volume of a sphere ($V = 4/3 \pi r^3$ where π is 22/7 or 3.14 and the r is the radius of the sphere or half of the diameter). Now you can ask them if they think the density will be the same no matter which method is used. An easy way to obtain the diameter of a sphere is to place it between two blocks of wood and then measure the distance between the blocks. Half of that will be the radius. If we multiply the radius by itself and then that answer by the radius again, we have r^3. Multiply by π (22/7) and then by 4/3, and you have the volume. Divide this answer by the mass of the object and you have the density.
2. When you have the 2 density measurements, you can talk about percent error. Decide which method is the more accurate. To find percent error, you first find the difference of the two densities and then divide by the density you decided was the most accurate. Round this answer off to the nearest hundredth. Move your decimal point 2 places to the right and you have a percent.

Example:	Density by displacement	Density by measurement
	1.9 g/cm³	1.6 g/cm³

a. find the difference: 1.9 - 1.6 = .3

b. divide by the more accurate (measurement):

$$\frac{.3}{1.6} = .19$$

c. move the decimal point 2 places to the right:
.19 = 19%

3. Obtain a vernier caliper and let the students measure the diameter of the object and then check the accuracy of the previous results.

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What's The Difference?

I. Topic Area

Density and Volume of Spheres

II. Introductory Statement

Density is the measure of mass per unit volume. It is defined by the formula D = m/v (density equals mass divided by volume) and is expressed in grams per cubic centimeter. Students should be able to measure the volume of a sphere by several methods. In this investigation the students will determine if it makes a difference in the density which method they use.

III. Math Skills

a. Measuring
b. Finding percent error
c. Using a vernier caliper
d. Multiplying fractions and decimals
e. Dividing fractions and decimals
f. Rounding off

Science Processes

a. Measuring
b. Recording data
c. Applying and generalizing

IV. Materials

Spherical (Hollow) Christmas ornaments
Graduated cylinder
Metric balance with weights
A liquid to measure the density

V. Key Question

"Does it matter what method of measuring volume we use?" "Will our densities be accurate no matter what method we use?"

VI. Background Information

By calculating the volume in several different ways, students should see that it really doesn't matter which method is used. A way of comparing these methods is by computing the percent error between the densities found.

VII. Management Suggestions

Let each child have a Christmas ornament. Suggested time is one class period for measurements and calculations. More time might be needed for discussion.

VIII. Procedure

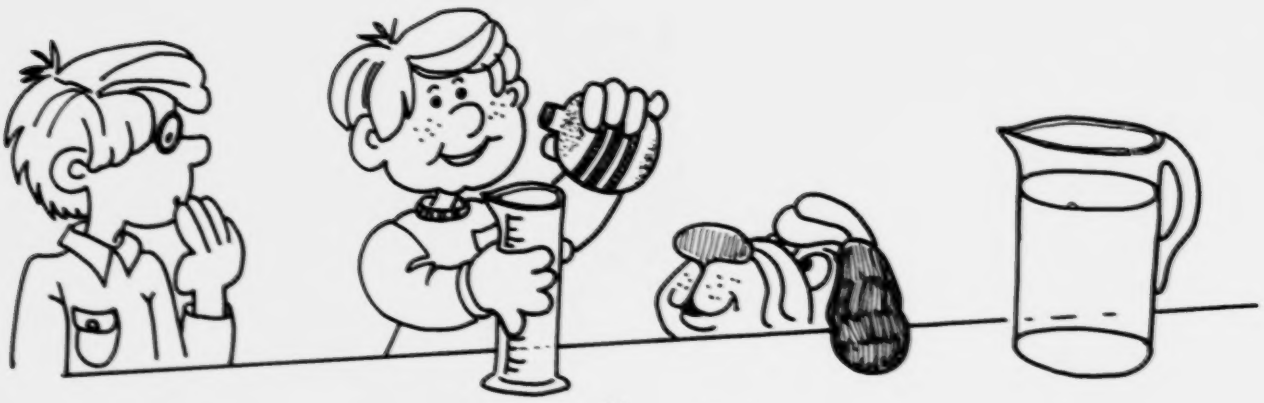
Give each child an ornament. Ask them to find the volume of the ornament in three different ways (direct measurment of volume of liquid it contains, using a vernier caliper, water displacement when submerged, or direct calculation using diameter of ornament). They should fill it with a liquid and find the mass of the liquid. By dividing the mass by the volume, they will find the density. Have them determine the percent error among the three densities found.

IX. What the Students Will Do

1. The students will estimate the volume of the ornament.
2. The students will calculate the volume of the ornament by 3 of 4 known methods.
3. The students will find the mass of the liquid the ornament holds.
4. By dividing the mass by the volume, the students will find the density of this liquid.
5. The students will compute the percent error in the different methods of finding the volume of a sphere.
6. The students will decide which is the best method.

X. Discussion

1. Was there much difference in the volumes using the different methods?
2. Which do you think was the most accurate?
3. Why can't we always use this method?
4. What other spherical objects could we fill with liquid?



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I. **Topic Area**

Density

II. **Introductory Statement**

Students will find the density of a variety of sports balls. The volume will be computed by finding the measure of the circumference and then determining the (1) diameter, (2) radius and (3) volume.

III. **Math Skills**

a. Estimating
b. Measuring circumference
c. Massing
d. Using the formula $C = d\pi$
e. Using the formula $V = 4/3\,\pi\, r^3$
f. Using the formula $D = m/v$
g. Graphing

Science Processes

a. Predicting and estimating
b. Measuring
c. Recording data
d. Interpreting data

IV. **Materials (Choose any six)**

Tennis ball
Basketball
Baseball
Softball
Volleyball
Soccer ball
Rubber ball
Ping pong ball
Golf ball
Croquet ball
Racket ball

V. **Key Question**

"If the sports balls used in this investigation are arranged in order from the lowest to highest density, what will that order be?"

"What is the density of each sports ball?"

VI. **Background Information**

To find the volume of a sphere we need to know the radius. By measuring the circumference we can find the diameter by dividing the circumference (C) by π : $d = C/\pi$. The radius is then found by dividing the diameter by 2 or it can be found directly by the formula $r = C/2\pi$.

VII. **Management Suggestions**

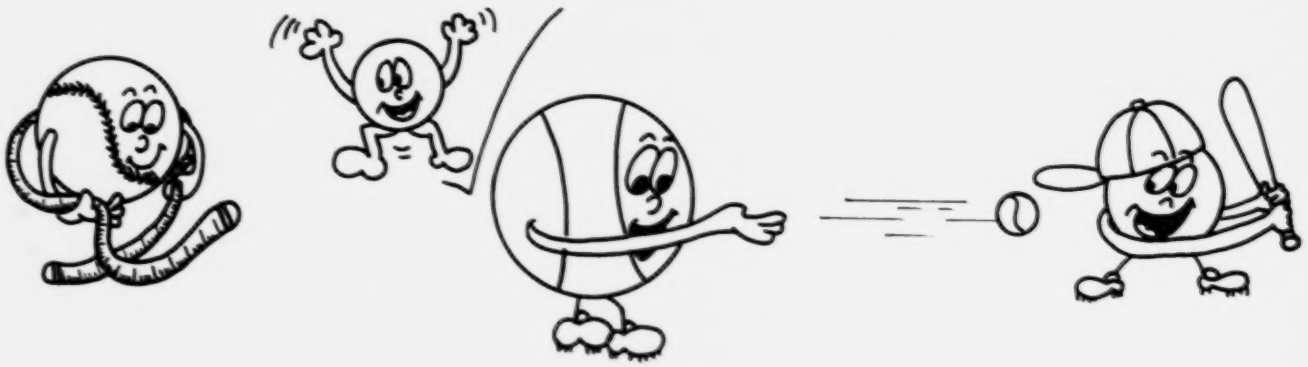
Have students collect a variety of sports balls. Allot six to each group. Interest is increased if the groups have as many different kinds of balls as possible. Working as teams, have each group rank order the sports balls from lowest to highest density by estimating. Also, have each member of the group estimate the density of each ball. Then have the groups complete the investigation and check their estimates.

IX. **What the Students Will Do**

1. Form teams of 3 to 5 students each.
2. Select six sports balls for their investigation.
3. Each will estimate the density of each of the balls.
4. As a team, they will arrive at a concensus as to the relative densities and arrange from lowest to highest densities.
5. As a team they will find the circumference of each ball and its mass, recording the information in the table.
6. Working individually and then comparing results, they will find the volume of each ball.
7. Working individually and then comparing results, they will find the density of each ball.
8. The team will then compare their measured and computed results with their estimates and describe what they found.

X. **Discussion**

Students should discuss the relationship of their estimates with the actual results.



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A Displaced Object

I. Topic Area

Density and Volume

II. Introductory Statement

Density is mass per unit volume. If you have two cubes the same size but one was heavier, it will be the more dense. In this investigation we are dealing with irregular shaped objects. To find the volume, we will use water displacement.

III. Math Skills

a. Measuring
b. Subtracting whole numbers and decimals

Science Processes

a. Measuring
b. Recording of data

IV. Materials

A selection of small objects made of brass, aluminum, copper, glass, clay, iron, steel, lead, wax and wood (Examples: keys, coins, candles, hardware)
Graduated cylinders
Metric balance and masses

V. Key Question

"In objects that are heavier than water, how does the volume compare with the loss of weight in water?"

VI. Background Information

In this investigation we are going to submerge irregular shaped objects in water to find the volume. The amount of water displaced will be the volume of the object. We will also find that the difference between the weight of the object in air and the weight in water will be very close to the volume of the object. As an extension, you might have the students find the density of each object and compare it to the chart below.

Table of Densities

Aluminum	0.79	Brass	8.5
Copper	8.9	Cork	.24
Iron	7.8	Lead	11.3
Paraffin	.9	Silver	10.5

VII. Management Suggestions

This can be done as a whole class activity. Have a small group (3-4) lead this activity. You will need one or two class periods depending on the amount of objects used and the depth to which this investigation is taken.

VIII. Procedure

Have a small group of students at the front of the class. Have a copy of the chart on either the chalkboard or overhead projector. Let one student hold the first object before the class, describe and weight it. This will be the "weight in air." Have a graduated cylinder filled to 100 ml. When the student places the object in the cylinder, the level of the water will rise. The amount it rises is the volume. If the cylinder is now weighed and the empty cylinder weight is subtracted, you will have "weight in water." The difference between "weight in air" and "weight in water" will be very close to the volume. We've called this the "loss of weight." By comparing the "loss of weight" with the water displacement, they will notice quite a similarity.

IX. What the Students Will Do

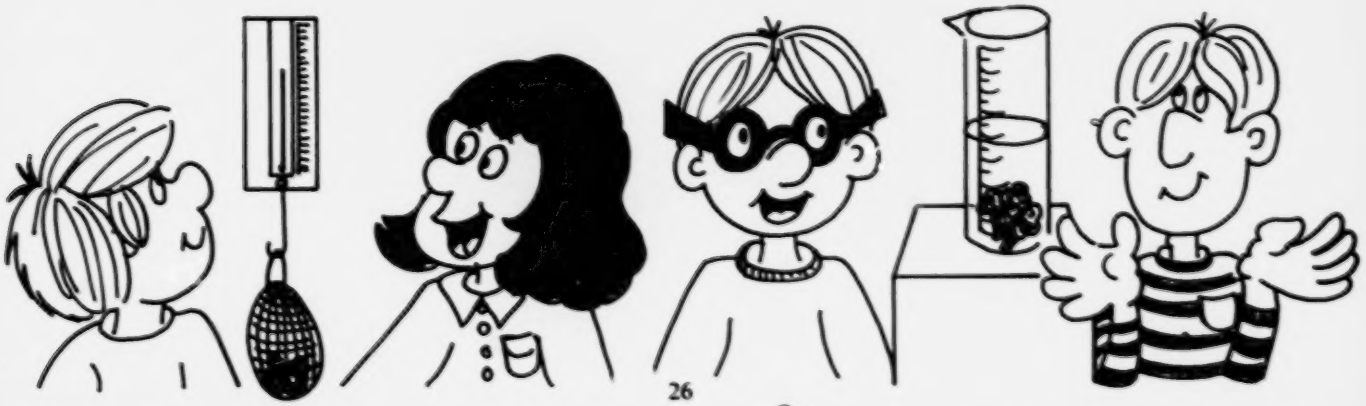
1. The students will find the weight of an empty graduated cylinder.
2. They will find the weight of the object in air.
3. They will find the amount of water displaced when the object is put in the graduated cylinder.
4. They will find the weight of the cylinder plus object.
5. They will subtract the weight of the empty graduated cylinder from the cylinder with object to find "weight in water."
6. They will find the difference between "weight in air" and "weight in water" to find "loss of weight."
7. The students will see how close the loss in weight is compared to the volume.

X. Discussion

1. What do you notice about the loss of weight and the volume? (They should be very close.)
2. Could we find your volume this way? Suggest ways to do this. (Fill a bathtub and find displacement, but it would be hard to measure "loss of weight in water.")

XI. Extension

1. Have the students find the densities of the various objects and compare to the chart.
2. Have the students calculate the percent error between the loss of weight and the volume.



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Fill 'er Up Gravel

1. Estimate the volume of air space (ml.) found in 100 ml. of gravel.
   100 ml. gravel contains _____ ml. air space.
2. Measure exactly 100 ml. of gravel in a graduated cylinder.
3. Pour it into a tin can. Don't pack it! Level the top.
4. Pour exactly 100 ml. water into the graduated cylinder.
5. Pour water from the graduated cylinder into the gravel.
   Pour exactly to the top but not over the gravel.
6. Record volume of water used.
7. Repeat steps 2-6 for trials 2 and 3.

TRIAL NUMBER	VOLUME of GRAVEL (ml.)	VOLUME of WATER (ml.)
1		
2		
3		
TOTAL		
AVERAGE		

Volume of Air Space Displaced. (Same as volume of water used.) _____

Ratio of Water to Gravel. _____

FORMULA:

$$\frac{\text{Ave. Volume of Water (ml.)}}{\text{Ave. Volume of Gravel (ml.)}} = \text{Ratio of Water to Gravel.}$$

Percent of Air Space In Gravel. _____

FORMULA:

$$\frac{\text{Ave. Volume of Water}}{\text{Ave. Volume of Gravel}} \times 100 = \text{percent of Space}$$

Difference Between My Predicted Volume of Space and the Actual (ml.) _____

To Compute the Average Volume of Gravel and of Water used:

$$\frac{\text{Trial \#1} + \text{Trial \#2} + \text{Trial \#3}}{3} = \text{Average}$$

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Fill'er Up-Sand

Name _____

Date _____ Class _____

1. Estimate the volume of air (ml.), if any, found in 100 ml. of sand.
   100 ml. sand contains _____ ml. air space.
2. See Fill'er Up - Gravel instructions #2-7 but use sand instead.
3. Graph to compare the volume of air space displaced in gravel and sand.
4. Graph to compare the percent of air space in gravel and sand.

Trial Number	Volume of Sand (ml.)	Volume of Water (ml.)
1		
2		
3		
Total (Sand)		
Average (Sand)		

	Volume of Gravel (ml.)	Volume of Water (ml.)
Total (Gravel) From Page		
Average (Gravel) From Page		

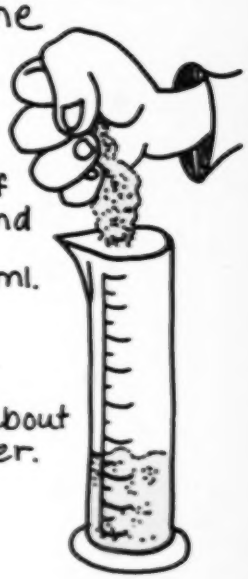
THE BOTTOM LINE

	GRAVEL	SAND
Volume of Air Space Displaced (Same as volume of water used)		
Ratio of Water to...		
Percent of Air Space in...		

Use these figures for the graphing exercise.

Difference between my predicted volume of space in sand and the actual.
_____ ml.

On a separate sheet of paper write a story about space in matter.



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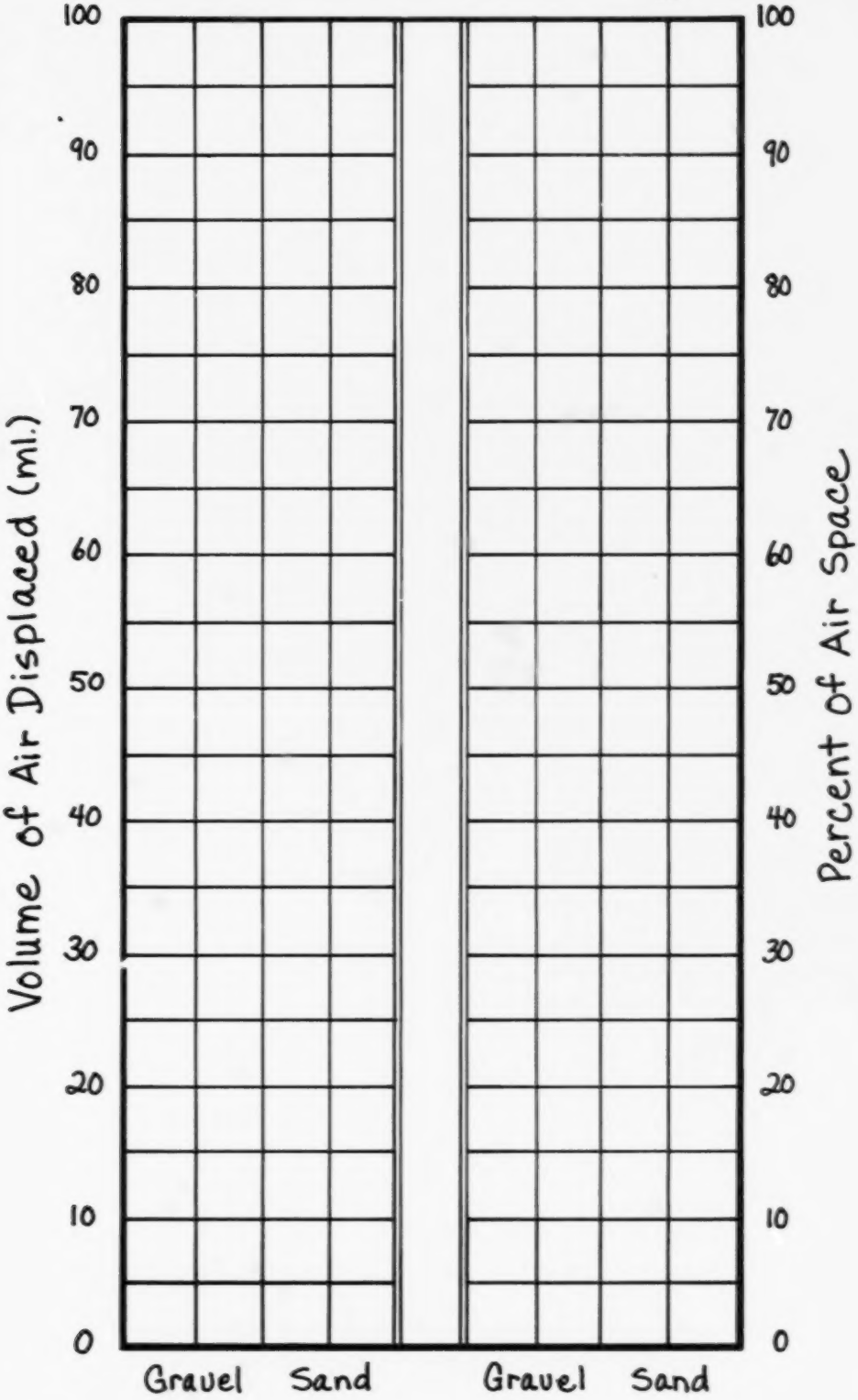
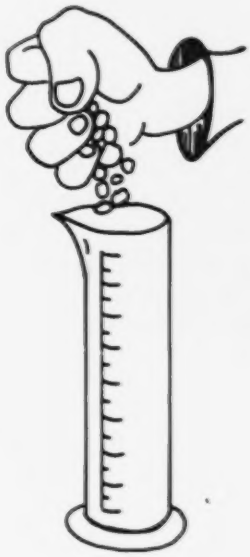
Fill'er Up-Sand



GRAPH TO COMPARE.



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A Salty Solution

1. Pour exactly 100ml. of water into a glass. Mark the top level on the glass with a marking pen.
2. Using a dry graduated cylinder, measure 50 ml. of salt.
3. Carefully pour one ml. of salt into the water, stir and dissolve. Check the water level. Continue this process until you see the water level begin to rise. STOP adding salt when the water level BEGINS to rise.
4. Record the amount of salt used.
5. Repeat steps 1-4 for trials 2 and 3.
6. Now, using 250 ml. of water, do steps 1-5.
7. Calculate the average amount of salt used with 100 ml. of water and again with 250 ml. of water.

$$\left(\text{average} = \frac{\text{Trial 1} + \text{trial 2} + \text{Trial 3}}{3}\right)$$

8. Calculate the ratio of salt to water for both solutions.

$$\left(\text{Ratio} = \frac{\text{average ml. of salt}}{\text{ml. of water}}\right)$$

9. Calculate the percentage of salt in each final solution.

$$\left(\text{Percentage} = \frac{\text{average ml. of salt}}{\text{ml. of water}} \times 100\right.$$

	100 ml. of water	250 ml. of water
SALT USED	Trial 1 ml.	ml.
	Trial 2 ml.	ml.
	Trial 3 ml.	ml.
	Average	
	Ratio	
	% salt	

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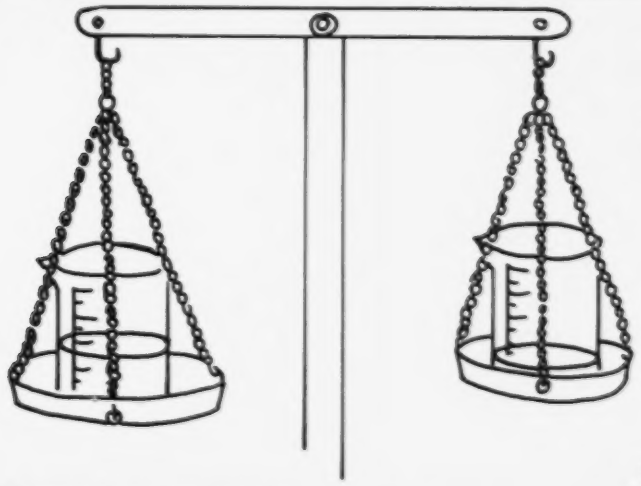
Wat-ar Densities?

1. Weigh your graduated cylinder empty and record on the chart below.
2. Measure 50 ml of water into your graduated cylinder.
3. Weigh the graduated cylinder with your water in it and record this data.
4. Subtract the two masses to find the mass of your water. Record this under the heading "Mass of Water."
5. Divide the mass of the water by the volume of the water to find your density and round off to the nearest hundredth.
6. Repeat using the indicated volumes of water.
7. Find the average of your densities.

The Standard Density of Water At Room Temperature Is 1 G/CM³ (or 1 g/ml). How Close Did You Come?

Volume	Mass Empty	Mass Filled	Mass of Water	Density of Water
50 ml				
100 ml				
150 ml				
200 ml				
250 ml				

Average Density =



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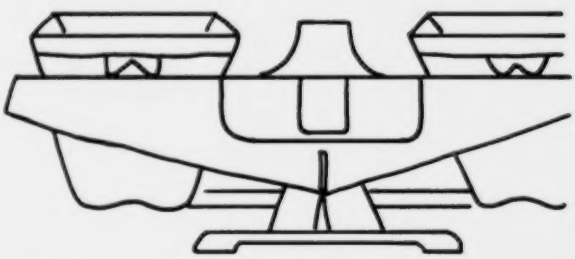
A SALTY PROBLEM

1. Weigh your graduated cylinder empty and record on the chart below.
2. Measure 10ml of salt into your graduated cylinder.
3. Weigh the graduated cylinder with your salt in it and record this data.
4. Subtract the two masses to find the mass of your salt Record this under the heading "Mass of Salt".
5. Divide the mass of the salt by the volume of salt to find your density and round off to the nearest hundredth.
6. Repeat using the indicated volumes of salt.
7. Find the average of your densities.

The Standard Density Of Table Salt Is 1.4 G/CM^3 (or 1.4 g/ml). How Close Did You Come?

VOLUME	MASS EMPTY	MASS FILLED	MASS OF SALT	DENSITY OF SALT

Average Density =



A SUPER SALTY SOLUTION

1. Pour 100ml. of water into a large graduated beaker. Mark the top level and weigh.
2. Measure 50 ml. of salt into a dry graduated cylinder.
3. Add Salt 1 ml. at a time to the water, stirring afterward, until the water level begins to rise. STOP, weigh the beaker, record the weight and amount of salt used. this is the NORMAL SOLUTION.
4. Continue adding the salt 1ml. at a time making sure you stir until the salt dissolves. When the salt no longer dissolves, STOP. This is the SATURATED SOLUTION.
5. Weigh the beaker again. Record the weight, new volume, and amount of salt used.
6. Repeat steps 1-5 for trials 2 and 3.

	NORMAL SOLUTION			SATURATED SOLUTION		
	Amount of salt used	Weight	Volume	Amount of salt used	Weight	Volume
Trial 1	ml	g	100ml	ml	g	ml
Trial 2	ml	g	100ml	ml	g	ml
Trial 3	ml	g	100ml	ml	g	ml
Average	ml	g	100ml	ml	g	ml

7. Compute the density of each solution (divide the average weight by the average volume)

Normal Solution Density = _____ g/ml

Saturated Solution Density = _____ g/ml

Which is closer to the true density of sea water (1.2 g/ml)?

8. Calculate the ratio of salt to water in each Solution. NORMAL _____ SATURATED _____

9. Calculate the percentage of salt in each Solution. NORMAL _____ SATURATED _____

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See Level

Liquid	Sample number	Container Weight	Weight of container + Liquid	Liquid Weight	Volume	Density	Average Density
Water	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						

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Which Way Is Up?

Identifying Length, Width and Height

length width height

Box	Color Measure	Color Measure	Color Measure	Volume
A				
B				
C				
D				
E				
F				
G				
H				

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MASSIVE BOXES

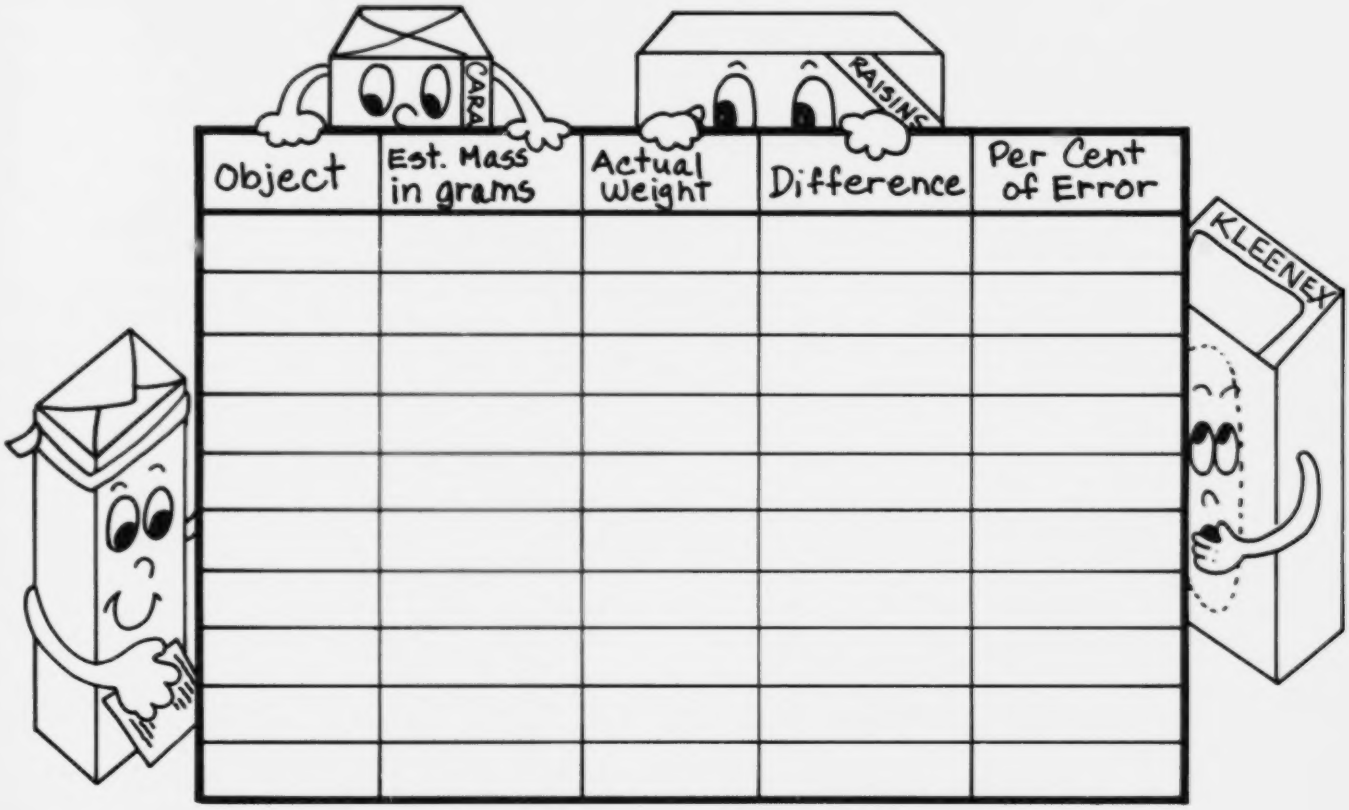
Name _____

How much does each object weigh? Can you, without handling, put the objects in order from lightest to heaviest?

Look at the 10 objects and list them in order lightest To heaviest.

1. _____ 5. _____ 9. _____
2. _____ 6. _____ 10. _____
3. _____ 7. _____
4. _____ 8. _____

Please estimate the mass in grams, determine the mass, and compute the per cent of error of your estimated mass and the actual mass for each object.



Object	Est. Mass in grams	Actual Weight	Difference	Per Cent of Error

MASSIVE BOXES

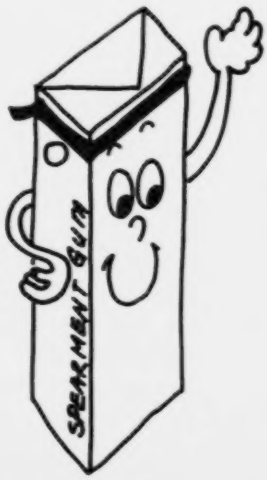
CAN YOU COMPUTE THE VOLUME AND DENSITY OF THE 10 OBJECTS?

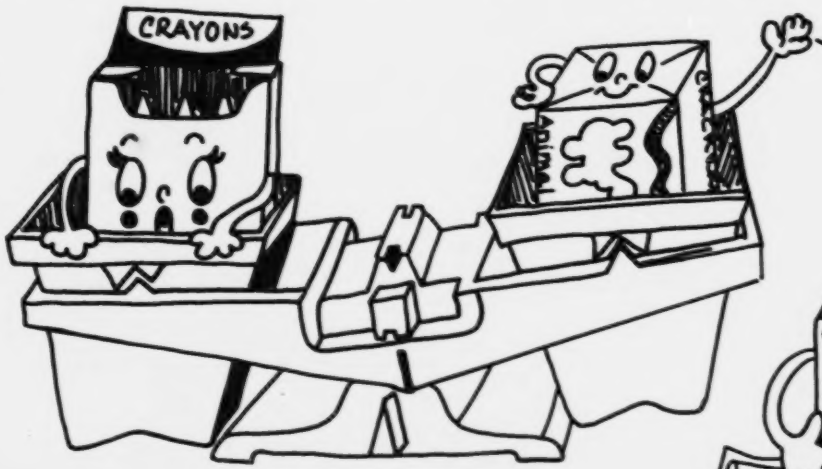
Predictions:

Which object has the smallest volume? _____
Which object has the least density? _____
which object has the largest volume? _____
Which object has the greatest density? _____

OBJECT	MASS IN GRAMS	VOLUME IN cm^3	DENSITY
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Describe your findings. Were there any surprises?





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Are You As Dense As I am?

NAME

PREDICTIONS:

Which sample will have the greatest density? _____

Which sample will have the least density? _____

Please explain the reasons for your choices. _____

_____

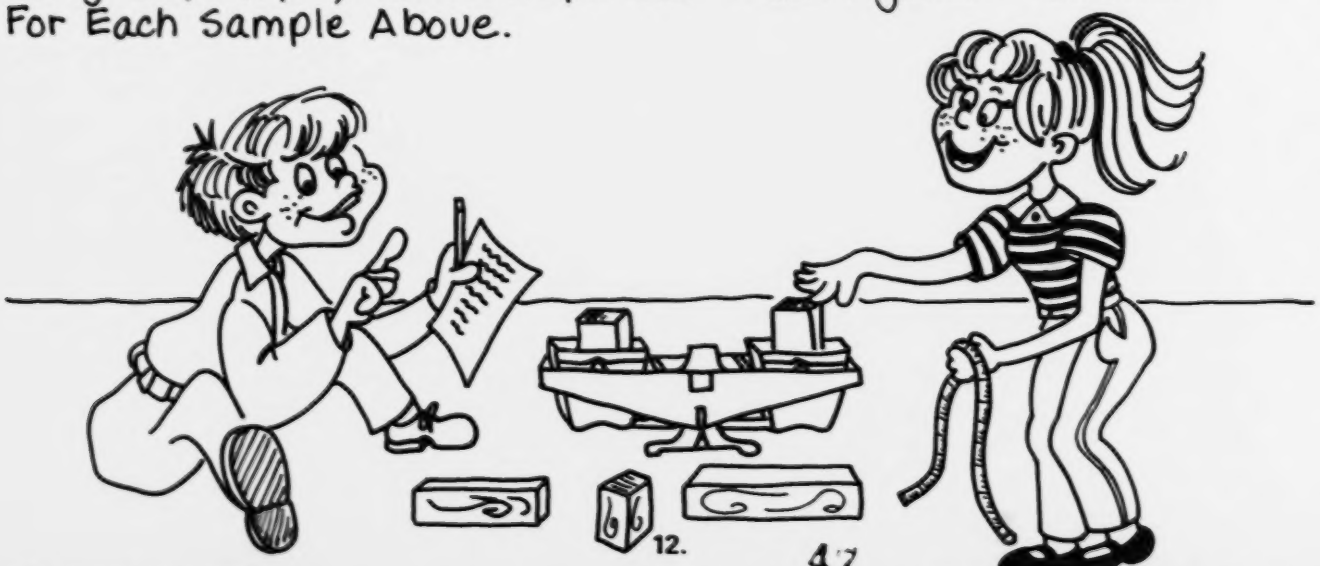
_____

_____

Please record your sample information on the chart below and then calculate the volume and density.

Sample	Length in cm	Width in cm	Height in cm	Volume in cm^3	Mass in grams	$d = \frac{m}{v}$

Using Graph Paper, Please Graph Your Mass Against Volume For Each Sample Above.



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Are You As Dense As Iam Again?

Name _____

Why are model planes made from balsa? Are some woods better for certain purposes than other woods?

PREDICTIONS:

Which wood sample is least dense? _____

Which wood sample is most dense? _____

Please record your sample information on the chart below. Then calculate the volume and density.

WOOD TYPE	LENGTH in cm	WIDTH in cm	HEIGHT in cm	VOLUME in cm^3	MASS in grams	$d = \frac{m}{v}$
1.						
2.						
3.						
4.						
5.						

WOOD	0.1 . 0.3 . 0.5 . 0.7 . 0.9 . 1.1 . 1.3 . 1.5 . 1.7 .

MY MYSTERY WOOD IS _____

13.

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FLOATING WOOD

Can You Predict the Floatation Line For a Block of Dry Pine?

1. Make four measures, each to the nearest millimeter, of each dimension of your boat: length, width, and height.
2. Measure along the four parallel edges in each case.
3. Find the average of each set of measures and enter into the table.
4. Compute the volume using the average measures.
5. Change this volume from mm^3 to cm^3 (divide by 1,000.)
6. Round to the nearest tenth of a cubic centimeter.

	LENGTH	WIDTH	HEIGHT
First Edge	mm	mm	mm
Second Edge	mm	mm	mm
Third Edge	mm	mm	mm
Fourth Edge	mm	mm	mm
Average	mm	mm	mm
	Volume = lwh ÷ 1000 =		cm^3

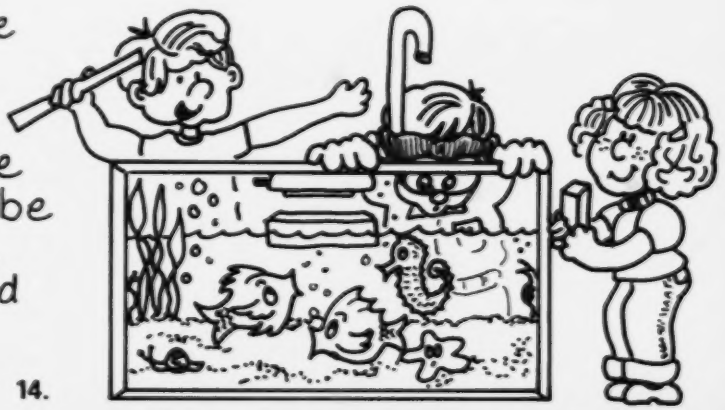
Volume of your block _____ cm^3

Mass of your block _____ grams

Density of your block _____ $grams/cm^3$

I predict the water line will be _____ mm from the bottom.

Lightly mark your block where you predict the water line will be if placed in water. Test to see how accurately you predicted the results.



14.

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AFLOAT

Use an empty pill bottle to find the densities of the oceans.

1. Find the volume.
   a. Measure the diameter.
   b. Find ½ the diameter = radius (r).
   c. Square the radius (r x r).
   d. Multiply by 3.14 (π).
   e. Multiply by the height.
2. Weigh the bottle empty.
3. Fill the bottle with water and reweigh.
4. The difference between full and empty is the mass.
5. Divide the mass by the volume ~ DENSITY!

Ocean	3.14 x r x r x height =	VOLUME	bottle empty	bottle full	ocean mass	Density
TAP						
SALT						

Now, choose a wooden boat. To calculate its density, do the following:

1. Weigh the boat (mass).
2. Measure the length, width and height.
3. Multiply to find the volume.
4. Divide the mass by the volume – DENSITY!

MY BOAT IS BLOCK # _____	Mass	Length	Width	Height	Volume	Density

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AFLOAT

Find the density of:

1. The tap water ocean _____ g/cm^3
2. The salt water ocean _____ g/cm^3
3. The wooden boat _____ g/cm^3

Remember: DENSITY = $\frac{\text{mass (grams)}}{\text{volume } (cm^3)}$

Compare the density of your wooden boat and the tap water ocean. Mark a line to show where you think your boat will float. TEST IT.

What will happen to the water line if you place your wooden boat into the salt water ocean?

_____

_____

Mark where the line will be and TEST IT.

Describe what you just noticed. Do cargo ships have this problem?
Explain what they must do to adjust for this?

_____

_____

_____

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SHIP SHAPE

Ship Use Permit Application

Name:

Ship's Name:

Ship's Dimensions in Centimeters:

Length _____ cm Width: _____ cm Draft: _____ cm

Calculated Deck Area: _____ cm^2

Volume of Cargo Area: _____ cm^3

Mass of ship When Empty: _____ grams

Calculated Maximum Cargo Weight: _____ grams

Number of cargo items to be allowed: _____

Description of Cargo Items: _____

For Office Use Only

TEST DATA:

Test Weight Carried _____ grams

Leakage: _____

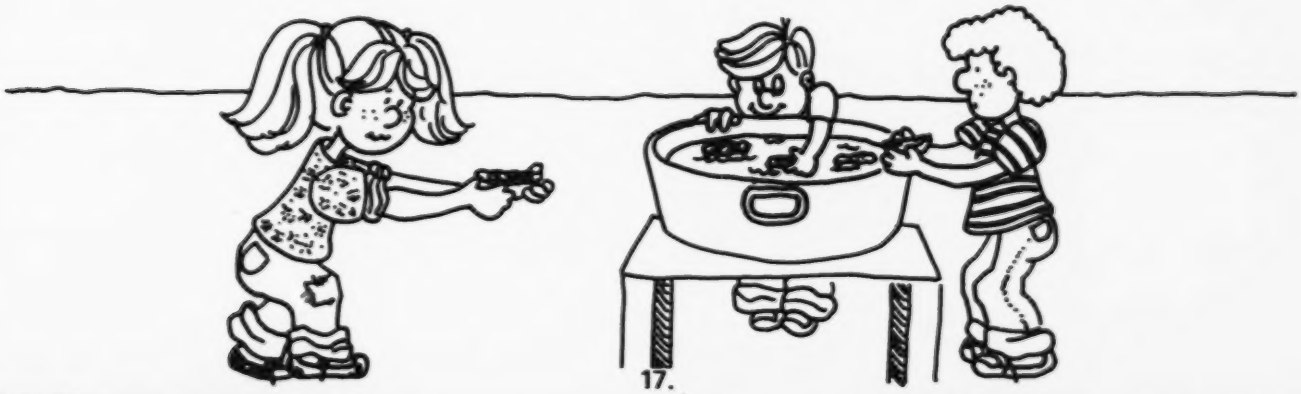
Stability When Loaded: _____

_____

Percentage of calculated Maximum Cargo Weight Allowed _____ %

_____ _____

Date Inspector's Signature



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Clay Boats

WILL IT FLOAT?
HOW MUCH WILL IT HOLD?

Draw your 3 best boat designs	Cargo weight	difference Between Cargo and Boat weight
I.		
II.		
III.		

1. On the reverse side tell why your best design is so special. What makes your boat hold more than others?

2. Why does your boat float? Observe the water level carefully.

18.

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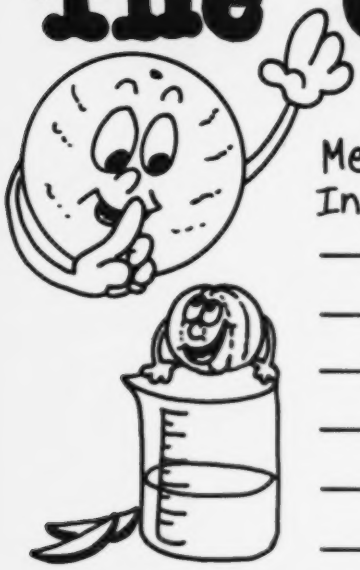
The Orange's Secret



Members of the Investigation Team

_____

_____

_____

_____

_____

_____

Indicate your prediction by circling the appropriate word Will it float or Sink?

float	Sink
float	Sink
float	Sink
float	Sink
float	Sink
float	Sink

This is what we found

Instruction	Orange Designations A	B	C	D	E
Unpeeled Oranges' Data:					
Mass in grams					
Water depth with orange					
Water depth without orange					
Difference in water depth*					
Density					
Average Density					
Peeled Oranges' Data:					
Mass in grams					
Water depth with orange					
Water depth without Orange					
Difference in water depth*					
Density					
Average Density					

* Volume in cubic centimeters.

a. How good was your prediction?

b. What is this average density of unpeeled oranges? Is it predictable?

c. What is the average density of peeled oranges?

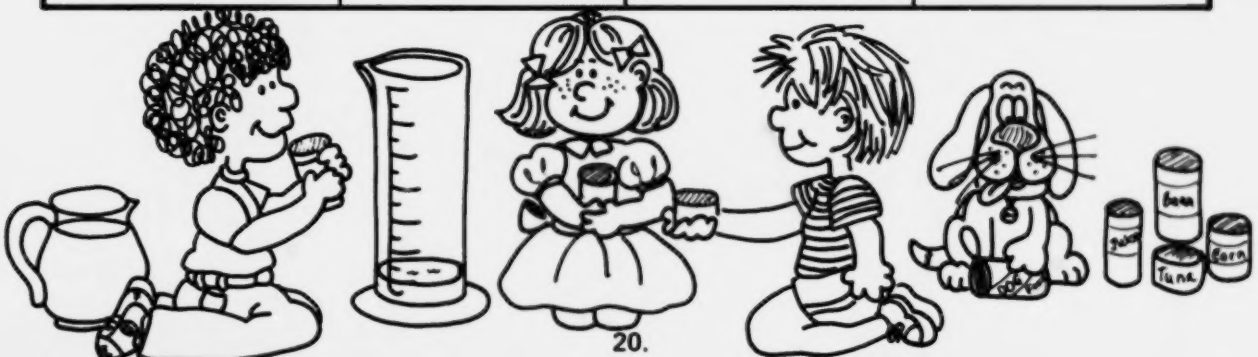
Can You Tell?

CYLINDER	ESTIMATE OF VOLUME	ACTUAL VOLUME	DIFFERENCE

TO FIND % ERROR:

1. Find the difference between your estimate and The actual volume.
2. Divide this answer by the actual mass and round off to the nearest hundredth.
3. Move the decimal point 2 places to the right and add the percent sign. You're Done!

CYLINDER	% ERROR MY GUESS	CLASS AVERAGE GUESS	% ERROR OF CLASS GUESS



TIN CAN SPACE

1. Estimate the volume of each of six different tin cans in cubic centimeters.
2. Find the volume of each by making appropriate measurements and calculations.
3. Check your answers by measuring the volumes using water and a graduated cylinder and compute your percent of error.

HERE ARE FORMULAS THAT WILL HELP YOU:

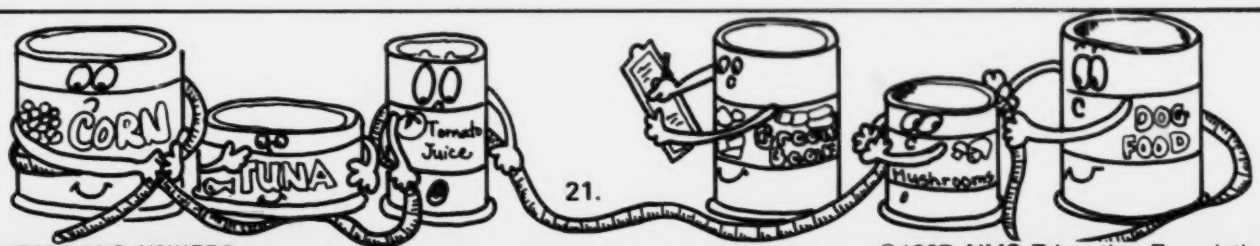
1. Area of Base = πr^2
2. Volume = $\pi r^2 h$
3. Per Cent of Error = $\frac{\text{Difference between estimated or calculated and the measured volume}}{\text{measured volume}}$

Can Number	Estimated Volume	Diameter in Cm	Radius in Cm	Area of Base	Height in Cm	Volume Calculated	Measured

PER CENT OF ERROR

Can Number	Difference Between Estimate & Actual	Per Cent of Error	Difference between Calculated & Actual	Per Cent of Error

OBSERVATIONS:



How much cargo will it hold?

Find:

CAN #	Diameter	radius	area	height	Volume
1					cm^3
2					cm^3
3					cm^3

Formulas:

radius = ½ x diameter

area = πr^2 ($\pi = 3.14$) ($r^2 = r \times r$)

Now:

1. Weigh can empty. Fill with cargo and reweigh. Subtract these weights. This is the mass of cargo.

2. Divide the mass by the volume. This is your density.

CARGO	Can Empty	Can Full	Cargo Mass	Cargo Volume	CARGO DENSITY
Salt Flour Rice Oats Beans					

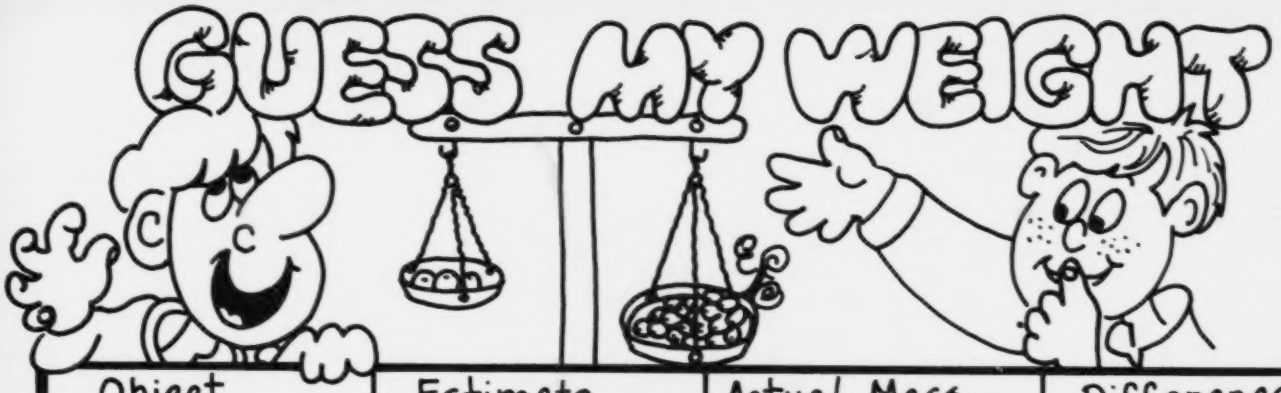
Cargo Rates

These rates are for 1 cubic _____.

CARGO	RATE
	$
	$
	$
	$
	$

My ship, the _____, holds _____ cubic _____.

GUESS MY WEIGHT



Object	Estimate	Actual Mass	Difference

Object	% Error of My Guess	Class Average Guess	% Error of Class Guess

TO FIND % ERROR:

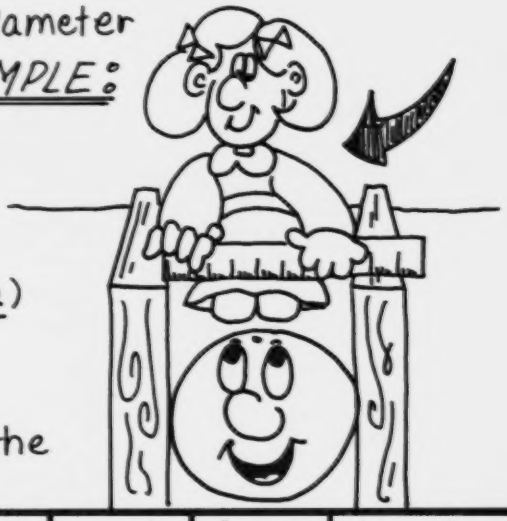
1. Find the difference between your estimate and the actual.
2. Divide this answer by the actual mass and round off to the nearest hundredth.
3. Move the decimal point 2 places to the right and add the percent sign. You're done!

FRUIT SALAD

"Does a spoonful of tomato have the same mass as a spoonful of grape?"

1. Choose 5 pieces of your fruit. (Are you a tomato or a grape?)
2. Weigh each sample and record.
3. Using 2 blocks of wood, measure the diameter of each sample.
4. To find the radius, divide the diameter by 2.
5. Cube the radius (Multiply the radius times the radius times the radius.)
6. Multiply this answer by π ($\pi = 3.14$ or $\frac{22}{7}$)
7. Multiply this answer by $\frac{4}{3}$. This will result in the volume.
8. To find the density, divide the mass by the volume.

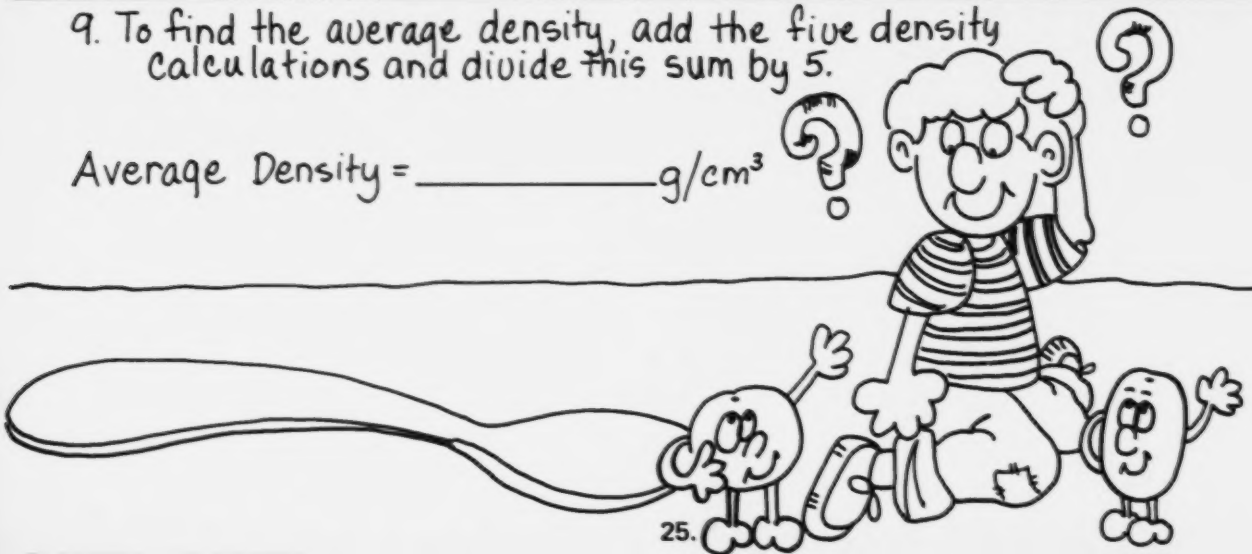
EXAMPLE:



fruit	mass	diameter	radius	(r^3)	πr^3	$\frac{4}{3}\pi r^3$	density

9. To find the average density, add the five density calculations and divide this sum by 5.

Average Density = _____ g/cm^3



JUST A SPOONFUL

"Does A Spoonful of Water Weigh the Same As Spoonsful of other liquids? YES_____ NO_____

1. Weigh and record the mass of your ornament empty.
2. Fill the ornament with a liquid. Weigh the filled ornament and record this measurement. Subtract these two masses and you will have the mass of the liquid. Record this.
3. Pour the liquid into a graduated cylinder and record this reading. (Remember: 1 milliliter is the same as 1 cubic centimeter and you will need the volume in cubic centimeters for density.)
4. Divide the mass by the volume and you will have the density of this liquid.
5. Repeat with the rest of the liquids.
6. Graph the densities of the liquids from lightest to heaviest.

Liquid	Empty Mass	Full Mass	Liquid Mass	Volume	Density
1.					
2.					
3.					
4.					
5.					

Now make a bar graph comparing the densities

Type of Liquid	Density (g/cm³) 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8
1.	
2.	
3.	
4.	
5.	

Now choose 1 liquid and five ornament sizes and find the following data:

Ornament	Mass	Volume	Density
1.			
2.			
3.			
4.			
5.			

Using graph paper, graph the mass against the volume and see what happens!

IT'S YOUR LOSS

Do Heavier Objects Displace More Water When Submerged In A Graduated Cylinder Than Lighter Objects? YES_____ NO_____

1. Fill a cylinder to a certain level and record this Level.
2. Place object in water and read new water level. Repeat this reading.
3. Subtract to find the difference. This difference is equal to the volume of the object. (1 milliliter = 1 cubic centimeter.)
4. Weigh the object. Divide the mass by the displacement to obtain density.

DENSITY BY DISPLACEMENT

Object	Level 1	Level 2	Difference	Density

DENSITY BY ANOTHER METHOD

Object	Mass	Volume	Density	% Error

REMEMBER: To find the volume of a sphere use this formula:
$V = \frac{4}{3} \pi r^3$ (Let $\pi = \frac{22}{7}$. The radius (r) is $\frac{1}{2}$ the diameter.)

What's The Difference?

"Does it matter which method of measuring volume we use?" "Will our density calculations be accurate no matter which method we use?"

1. Pick three of the following four methods of measuring the volume of your sphere and fill in the chart.

METHOD 1: Direct measurement of volume of liquid it contains. Fill your sphere with a liquid. Pour this liquid into a graduated cylinder and read the measure. Remember that 1 milliliter of water equals 1 cubic centimeter.

METHOD 2: Using a vernier caliper. Obtain a vernier caliper from your teacher. Measure the diameter of the ornament. Use this formula to compute the volume:

$V = \frac{4}{3} \pi r^3$ (r = radius or half the diameter.)

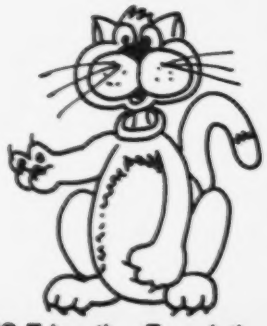
METHOD 3: Water displacement when submerged. Fill a beaker to a level which will cover your ornament when submerged. Make sure the ornament will fit into the cylinder. Submerge the ornament and read the new measure. The difference between the level before the ornament was added and after the ornament was added will give the volume (Remember that 1 milliliter of water equals 1 cubic centimeter.)

METHOD 4: Direct measurement of diameter. Place your ornament between two books or blocks of wood. By measuring the distance between these you will find the diameter. Use this formula to compute the volume:

$V = \frac{4}{3} \pi r^3$ (r = radius or half the diameter.)

2. Weigh the ornament empty and record. Weigh the ornament filled with your liquid. Record and find the difference. This will be the mass of the liquid. Record.

3. Divide this mass by each of the volume measurements obtained. This will give you three measurements of density. Which do you think is most accurate? Choose One.



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What's The Difference?

4. To find the % error of the other two densities, find the difference between the most accurate density chosen in 3 and one of the other two densities. Divide this difference by the most accurate density. Round off to the nearest hundredth and move your decimal point 2 places to the right. This is your % error.

EXAMPLE: density by method 1 $1.7\ g/cm^3$ density by method 2 $1.9\ g/cm^3$ (chosen as most accurate)

find the difference: $1.9 - 1.7 = .2$

divide by the most accurate method: $\frac{.2}{1.9} = .105$ rounded off = .11

move decimal point 2 places to the right: .11 = 11%

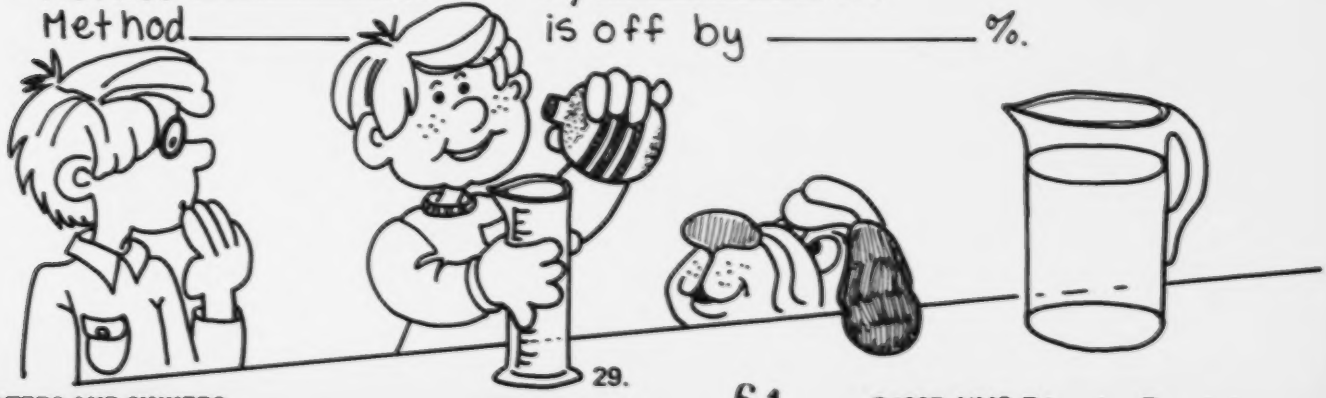
Add the percent sign and you have the answer: 11%

method number	volume	empty mass	full mass	liquid mass	density

I choose Method _____ To Be The Most Accurate.

Method _____ is off by _____ %.

Method _____ is off by _____ %.



PLAY BALL!

My name is _____

Members of my group are: _____

_____ _____

_____ _____

Sports Balls We Used	Our Estimates of Densities	Actual Densities	Our Group's Rankings*	Actual Rankings

*Lowest is 1, Highest is 6

These are our results:

Sport Ball	Mass in Grams	Circumference in Cm	Diameter in Cm	Radius in Cm	Volume in Cm^3	Density

Here is what we discovered:

_____

_____

_____

_____

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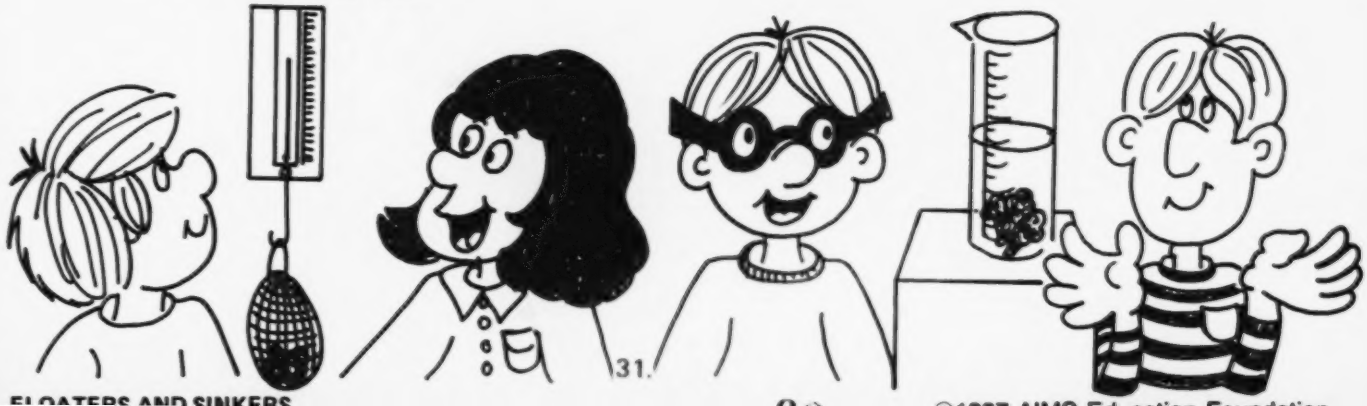
A Displaced Object

"In objects that are heavier than water, how does the volume compare with the loss of weight in water."

1. Find the weight of each object in air and water in grams.
2. Find the volume of each in milliliters by displacement.
3. Compare the volume and loss of weight.

OBJECT	Weight in air	Weight in water	Loss of Weight	Volume in ml.
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

What do you notice about the loss of weight and the volume.



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A Displaced Object

1. Using the weight and volume previously found, find the density of each object.

DENSITY = mass (weight) divided by volume.

OBJECT	WEIGHT	VOLUME	DENSITY

NOW MAKE A BAR GRAPH SHOWING THE DENSITIES.

OBJECT	DENSITY

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